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3 TO 6 IN. SHRAPNEL SHELLS
3 TO 6 IN. HIGH EXPLOSIVE SHELLS
AND
THEIR CARTRIDGE CASES

BY
ETHAN VIALL
MANAGING EDITOR *American Machinist*,
MEMBER AMERICAN SOCIETY OF MECHANICAL ENGINEERS,
MEMBER FRANKLIN INSTITUTE

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FOREWORD

No organization could have been better fitted than the *American Machinist* for the task of collecting and presenting the manufacturing methods of our arsenals. The average reader does not realize the enormous amount of detail involved in a task of this kind.

The *American Machinist* has in this work demonstrated its public spirit and patriotism.

HOWARD E. COFFIN,
Chairman of Munitions Committee,
Council of National Defense.

PREFACE

The purpose of publishing this material at the present time is to give shop men, engineers and manufacturers an accurate knowledge of the sizes, tools, shop work and gages for the more commonly used United States shells and cartridge cases.

While a large part of the detail work connected with the gathering of the material incorporated in this book has fallen to my share, it is to the staff of the *American Machinist* as a whole that the real credit belongs, as each member stood ready at all times to do his part and more.

ETHAN VIALL.

NEW YORK,
July, 1917.

CONTENTS

PAGE

FOREWORD v

PREFACE vii

I

3 IN. COMMON SHRAPNEL 1

II

3 IN. COMMON SHELLS (HIGH EXPLOSIVE) 26

III

3 IN. NAVAL SHELLS 48

IV

3.8 TO 6 IN. SHRAPNEL AND HIGH EXPLOSIVE SHELLS 56

V

6 IN. NAVAL SHELLS 62

VI

3 TO 6 IN. CARTRIDGE CASES 71

INDEX 95

The United States 3-in. common shrapnel, familiarly known as a 15-pounder, carries a charge of 238 hexagon-shaped lead balls, 0.5 in. at their largest diameter and 0.45 in. at the flats. Back of the balls is a charge of 1180 grains of shrapnel powder. Screwed into the front end of the projectile is a combination fuse communicating with the powder chamber through a small tube, the shrapnel powder being held in place by means of a small plug of dry guncotton. This guncotton also acts as an aid to ignition. The fuse may be set for time explosion, or it will explode on impact. The dimensions of the case forging are given in Fig. 1. These forgings must be thoroughly annealed and pass the following physical tests: Elastic limit, 60,000 lb.; tensile strength, 95,000 lb.; elongation, not less than 15 per cent.; contraction not less than 30 per cent. The only requirement as to chemical composition is that neither the sulphur nor phosphorus content shall exceed 0.045 per cent.

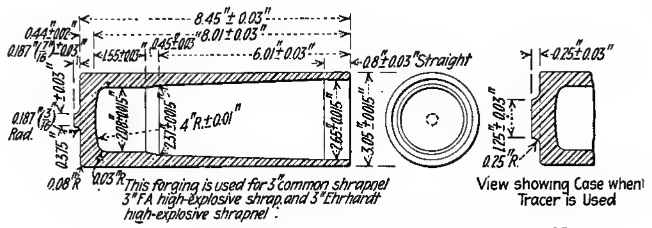

FIG. 1. DIMENSIONED FORGING FOR 3-IN. COMMON SHRAPNEL

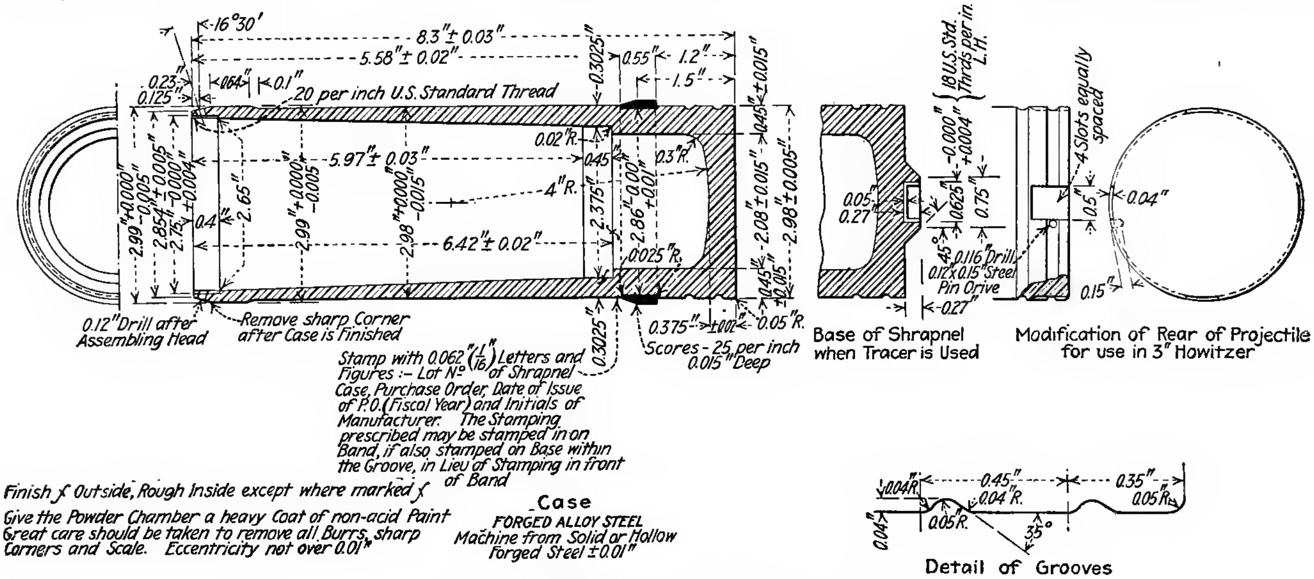

FIG. 2. DIMENSIONED FINISHED CASE

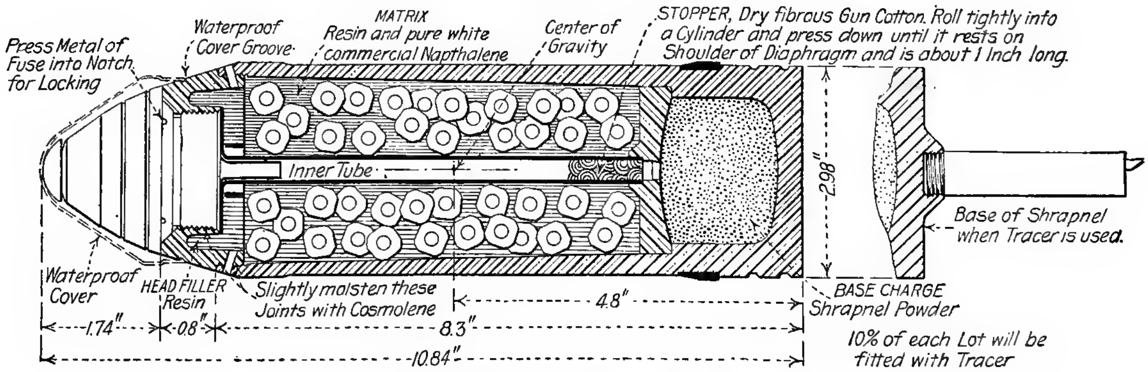

FIG. 3. DETAILS OF COMPLETE PROJECTILE

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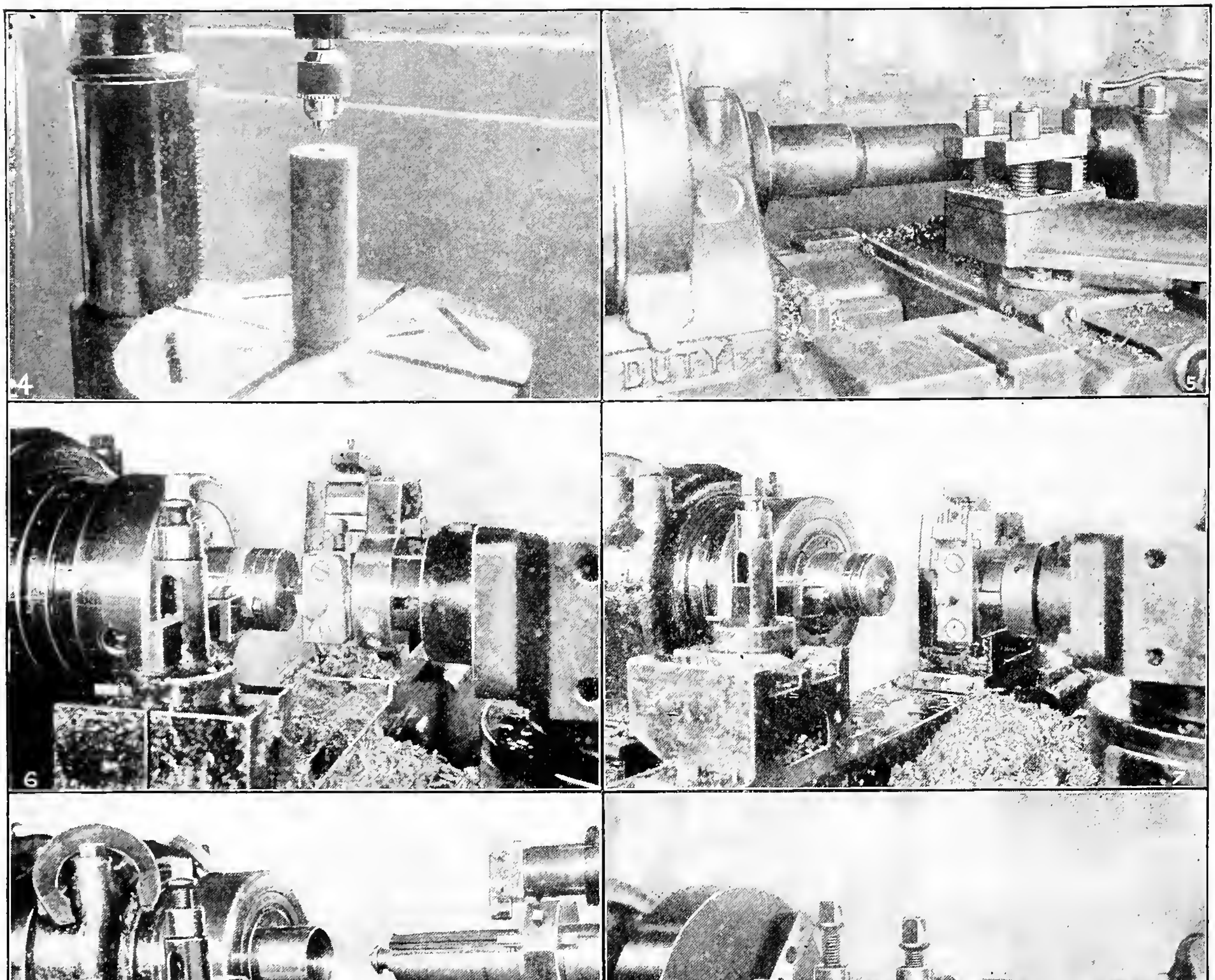


FIGS. 4 TO 11. VARIOUS OPERATIONS ON 3-IN. COMMON SHRAPNEL CASES

Fig. 4—Centering in drilling machine. **Fig. 5**—Turn body on lathe. **Fig. 6**—Finish outside (without tracer support). **Fig. 7**—Finish outside (with tracer support). **Fig. 8**—Finish interior on automatic. **Fig. 9**—Turning the bands. **Fig. 10**—Hydraulic testing apparatus. **Fig. 11**—Tapping for head.

LATHE TOOLS

Kind of Tool	Size: Stock	Size: Width C	Kind of Steel	Face To Be Ground	Hor. Angle Deg.	Ver. Angle Deg.
Finishing	1¼x⅝	⅜, ½, ⅝	H	Side A	90½	4
	1x½	⅜, ½	H	Side B	90½	4
	1x½	¼, 5/16, ⅜, 7/16, ½	C	End C	0	6
				Top D	105	0
Parting	1x½	⅛, ¼	H	Side A	90	3
	1x½	1/16, 3/32, ⅛, 5/32, 3/16, 7/32, ¼, 5/16, ⅜	C	Side B	91	3
				End C	0	10
				Top D	91	0
Round Nose	1x½	1/16, 3/32, ⅛, 5/32, 3/16, 7/32, ¼, 5/16, ⅜	C	Side A	90½	3
				Side B	90½	3
				End C	F	10
				Top D	91	0
Roughing-Blunt Right Hand	1x½		H	Side A	F2	6
				Side B	F2	6
	1¼x⅝		H	End C	F2	6
				Top D	98	14
Roughing-Sharp Right Hand	1x½		H	Side A	F1	6
				Side B	F1	6
	1¼x⅝		H	End C	F1	6
				Top D	98	22
Side Right Hand	1x½		C	Side A	85	6
				End C	35	6
				Top D	91	12
Inside Bend Right Hand	1x½		C	Side A	135	6
				End C	15	6
				Top D	81½	8½
Diamond Point Right Hand	1x½		C	Side A	48	13
				Side B	48	10
				End C		
				Top D	105	8½

Kind of Tool	Size: Stock	Size: Width C	Kind of Steel	Face To Be Ground	Hor. Angle Deg.	Ver. Angle Deg.
Bent Finishing Left Hand	1¼x⅝	⅜, ½, ⅝	H	Side A	135½	4
	1x½	⅜, ½	H	Side B	45½	4
	1x½	¼, 5/16, ⅜, 7/16, ½	C	End C	45	6
				Top D	100½	0
Bent Parting Left Hand	1x½	⅛, ¼	H	Side A	136	3
	1x½	1/16, 3/32, ⅛, 5/32, 3/16, 7/32, ¼, 5/16, ⅜	C	Side B	45	3
				End C	45	10
				Top D	91	0
Bent Round-Nose Left Hand	1x½	1/16, 3/32, ⅛, 5/32, 3/16, 7/32, ¼, 5/16, ⅜	C	Side A	136	3
				Side B	45	3
				End C	F	10
				Top D	91	0
Roughing-Blunt Left Hand	1x½		H	Side A	F2	6
				Side B	F2	6
	1¼x⅝		H	End C	F2	6
				Top D	98	14
Roughing-Sharp Left Hand	1x½		H	Side A	F1	6
				Side B	F1	6
	1¼x⅝		H	End C	F1	6
				Top D	98	22
Side Left Hand	1x½		C	Side A	85	6
				End C	35	6
				Top D	91	12
Inside Bend Left Hand	1x½		C	Side A	135	6
				End C	15	6
				Top D	81½	8½
Diamond Point Left Hand	1x½		C	Side A	48	10
				Side B	48	13
				End C		
				Top D	105	8½

Kind of Tool	Size: Stock	Size: Width C	Kind of Steel	Face To Be Ground	Hor. Angle Deg.	Ver. Angle Deg.
Bent Finishing Right Hand	1¼x⅝	⅜, ½, ⅝	H	Side A	45½	4
	1x½	⅜, ½	H	Side B	135½	4
	1x½	¼, 5/16, ⅜, 7/16, ½	C	End C	45	6
				Top D	100½	0
Bent Parting Right Hand	1x½	⅛, ¼	H	Side A	45	3
	1x½	1/16, 3/32, ⅛, 5/32, 3/16, 7/32, ¼, 5/16, ⅜	C	Side B	136	3
				End C	45	10
				Top D	91	0
Bent Round-Nose Right Hand	1x½	1/16, 3/32, ⅛, 5/32, 3/16, 7/32, ¼, 5/16, ⅜	C	Side A	45	3
				Side B	136	3
				End C	F	10
				Top D	91	0
Bent Roughing-Blunt Right Hand	1x½		H	Side A	F2	6
				Side B	F2	6
	1¼x⅝		H	End C	F2	6
				Top D	104	8
Bent Roughing-Sharp Right Hand	1x½		H	Side A	F1	6
				Side B	F1	6
	1¼x⅝		H	End C	F1	6
				Top D	108	15
Bent Side Right Hand	1x½		C	Side A	45	6
				End C	75	6
				Top D	98½	8½
Boring	3/16, ¼, 5/16, ⅜, ½, ⅝, ¾, ⅞, 1		C	Side A	60	12
				Side B	60	12
				End C	0	
				Top D	90	0

Kind of Tool	Size: Stock	Size: Width C	Kind of Steel	Face To Be Ground	Hor. Angle Deg.	Ver. Angle Deg.
Brass	1x½		H	Side A	70	10
				Side B	70	6
				End C	25	10
				Top D	90	0
Bent Brass Right Hand	1x½		H	Side A	45	10
				Side B	95	6
				End C	50	10
				Top D	90	0
Bent Brass Left Hand	1x½		H	Side A	85	6
				Side B	45	10
				End C	50	10
				Top D	90	0
Brass (F.A.)	1x½		C	Side A	70	13
				Side B	70	13
				End C	0	25
				Top D	90	0
Bent Brass (F.A.) Right Hand	1x½		C	Side A	40	13
				Side B	100	13
				End C	30	25
				Top D	90	0
Bent Brass (F.A.) Left Hand	1x½		C	Side A	100	13
				Side B	40	13
				End C	30	25
				Top D	90	0
Roughing (F.A.)	1x½		H, C	Side A	F1	10
				Side B	F1	10
				End C	F1	10
				Top D	98	22
Bent Roughing (F.A.) Right Hand	1x½		H, C	Side A	F1	10
				Side B	F1	10
				End C	F1	10
				Top D	108	15
Bent Roughing (F.A.) Left Hand	1x½		H, C	Side A	F1	10
				Side B	F1	10
				End C	F1	10
				Top D	108	15
Bent Roughing-Blunt Left Hand	1x½		H	Side A	F2	6
				Side B	F2	6
	1¼x⅝		H	End C	F2	6
				Top D	104	8
Bent Roughing-Sharp Left Hand	1x½		H	Side A	F1	6
				Side B	F1	6
	1¼x⅝		H	End C	F1	6
				Top D	108	15
Bent Side Left Hand	1x½		C	Side A	45	6
				End C	75	6
				Top D	98⅓	8½
Boring Inserted Tool			H	Side A	60	12
				Side B	60	12
				End C	0	
				Top D	90	0

F = Former used on Grinding machine. F1 = Former No. 1. F2 = Former No. 2. H = High speed steel. C = Carbon steel.

Fig. 12. STANDARD LATHE TOOLS FOR GENERAL SHOP USE

OPERATION 1. CENTERING

Transformation—Fig. 13. Machine Used—Drilling machine, Fig. 4. Number of Operators per Machine—One. Work-Holding Devices—Arbor, Fig. 14. Tool-Holding Devices—Drill chuck. Cutting Tools—No. 42 combination center drill. Cut Data—350 r.p.m. Production—1200 per 8 hr. Note—A little red lead is used where drilled.

OPERATION 2. TURN BODY

Transformation—Fig. 15. Machine Used—Le Blond 17-in. lathe, Fig. 5. Number of Machines per Operator—Three. Work-Holding Devices—Centering chuck, Fig. 16. Cutting Tools—Left-hand turning tool, Fig. 12. Number of Cuts—One. Cut Data—50 ft. surface speed; 60 r.p.m.; 0.040-in. feed. Average Life of Tool Between Grindings—15 to 20 cases. Gages—Length from base to bourrelet, Fig. 17; combination maximum and minimum snap, Fig. 18; maximum, rear of band ring, Fig. 19; minimum rear of band ring, Fig. 20. Production—250 per 8 hr. Note—Speed given is maximum, as lower speed is used on harder cases.

OPERATION 3. FINISH OUTSIDE (CASE WITHOUT TRACER SUPPORT)

Transformation—Fig. 21. Machine Used—Potter & Johnston automatic, Fig. 6. Number of Machines per Operator—Two. Tool-Holding Devices—Facing-tool holder, forming-tool holder, tool post. Cutting Tools—Facing tool, Fig. 22; form tool, Fig. 23; knurl, Fig. 24. Cut Data—40 to 70 surface speed; 56 to 90 r.p.m.; fast speed and feed used for knurl and end work. Coolant—Zurn cutting oil. Special Fixtures—Internal split collet; bushing for collet, Fig. 25. Gages—Maximum and minimum width of band seat, Fig. 26; position of crimping grooves, Fig. 27; combination snap, diameter of band seat, Fig. 28; thickness of base and test piece, Fig. 29; position and width of band seat, Fig. 30. Production—300 per 8 hr.

OPERATION 3-A. FINISH OUTSIDE (CASE WITH TRACER SUPPORT)

Transformation—Fig. 31. Machine Used—Fig. 7. Cutting Tools—Facing tool, Fig. 32. Gages—Combination sheet gage, Fig. 33. Note—This operation is exactly the same as operation 3, except for different facing tool and one gage.

OPERATION 4. FINISH INTERIOR (AND BOURRELET WHEN CASES ARE FINISHED AT FRANKFORD ARSENAL)

Transformation—Fig. 34. Machine Used—Potter & Johnston automatic, Figs. 8 and 9. Number of Machines per Oper-

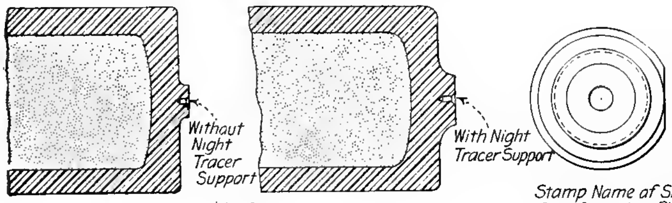


FIG. 13

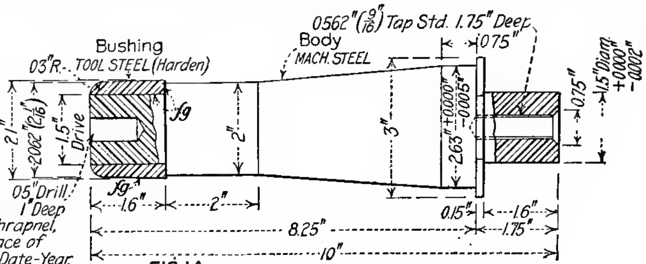


FIG. 14

OPERATION 1

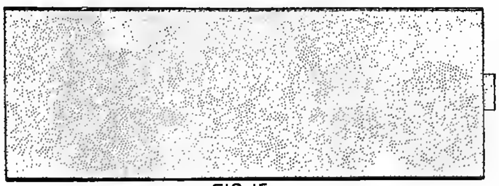


FIG. 15

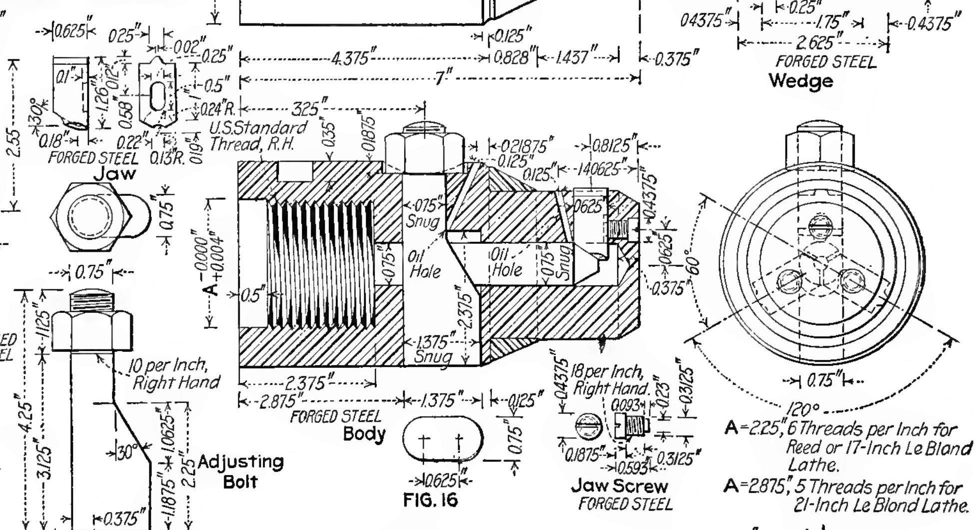


FIG. 16

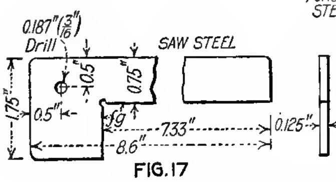


FIG. 17

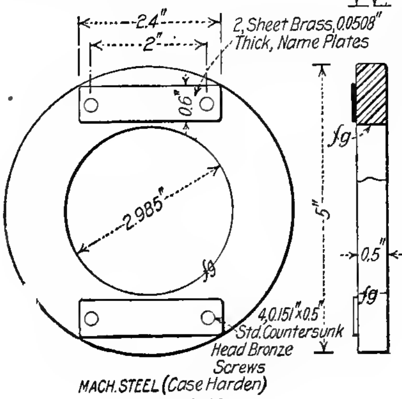


FIG. 19

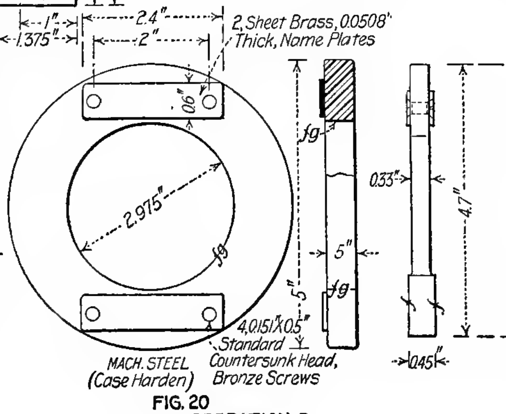


FIG. 20

OPERATION 2

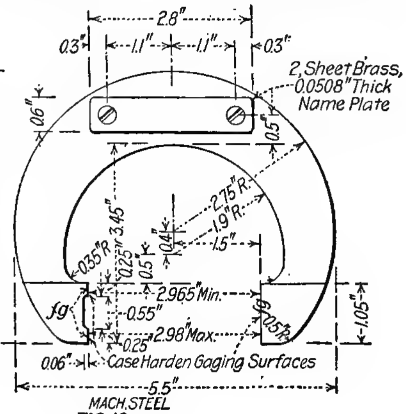


FIG. 18

ator—Two. Work-Holding Devices—Split chuck. Tool-Holding Devices—Rough boring bar; finish boring bar; tool holder for rough bourrelet, Fig. 35; tool post. Cutting Tools—Rough diaphragm-seat cutter, Fig. 36; rough boring tool, Fig. 36; rough facing tool, Fig. 36; finish diaphragm-seat cutter, Fig. 36; finish boring tool, Fig. 36; finish facing tool, Fig. 36; chamfering tool, Fig. 36; rough outside beveling tool, Fig. 37; turning tool for bourrelet, Fig. 35; square-nose lathe tool, Fig. 12; finish beveling tool, Fig. 37; No. 2½ geometric tap. Cut Data—50 ft. surface speed; 60 r.p.m. working speed; 35 r.p.m. tapping speed; 20 ft. surface speed. Coolant—Zurn oil. Gages—Maximum and minimum depth of diaphragm seat, Fig. 38; combination maximum and minimum diameter diaphragm seat, Fig. 39; combination maximum and minimum diameter rear of thread, Fig. 40; combination length of case, Fig. 41; combination maximum and minimum outside diameter and taper of mouth, Fig. 42; combination snap, bourrelet diameter, Fig. 28; maximum ring, bourrelet diameter, Fig. 43; minimum ring, bourrelet diameter, Fig. 44; maximum thread, plug, Fig. 45; minimum thread, plug, Fig. 45; maximum and minimum diameter, powder chamber, Fig. 46. Production—180 per 8 hr. Note—Powder chamber is machined by forgers.

OPERATION 5. ASSEMBLE BAND

Note—This is exactly the same as for the 3-in. common steel shell, except that only 1000-lb. pressure is used, on account of the thinner wall of the case.

OPERATION 6. HYDRAULIC TEST

Number of Operators—One. Description of Operation—Operator places case in fixture, mouth down, pours a cup of water in top of fixture over end of case, turns on 1000-lb. hydraulic pressure and watches water and case for bubbles or jets. Apparatus and Equipment Used—Special fixture, Fig. 47; pressure pump. Production—1200 per 8 hr.

OPERATION 7. TURN BANDS

Transformation—Fig. 48. Machine Used—Fig. 9. Gages—Finished band profile and position, Fig. 49. Note—Operation same as for 3-in. common steel shell.

OPERATION 8. TAP FOR NIGHT TRACER

Transformation—Fig. 50. Machine Used—Warner & Swasey turret lathe, Fig. 51. Number of Operators per Machine—One. Tool-Holding Devices—Tap holder, drill holder, recessing-tool holder, Fig. 52. Cutting Tools—Drill, reamer, Fig. 53; recessing tool, Fig. 54; tap, Fig. 55. Cut Data—334 r.p.m. machinery speed; 58 r.p.m. tapping speed. Coolant—Zurn oil. Gages—Combination depth, Fig. 56; maximum and minimum thread, plug, Fig. 57. Production—185 per 8 hr.

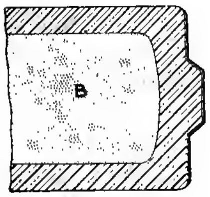


FIG. 31

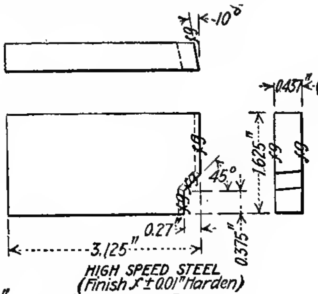


FIG. 32

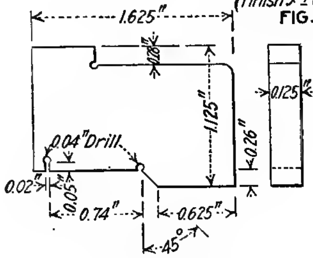


FIG. 33

OPERATION 3A

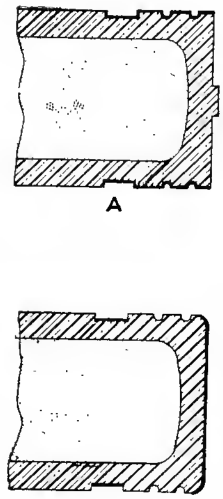


FIG. 21

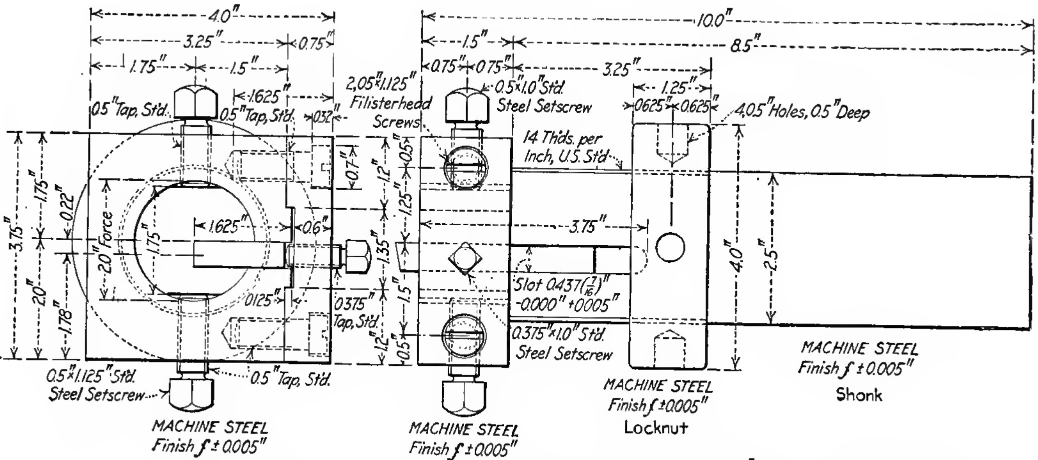
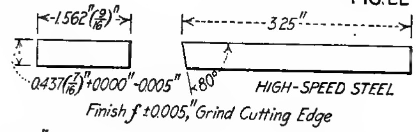
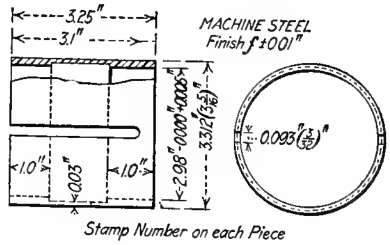


FIG. 22



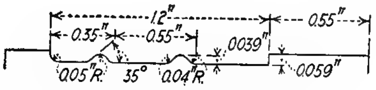
Facing Tool

FIG. 22

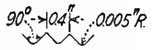


Bushing for Collet on P. & J. Automatic

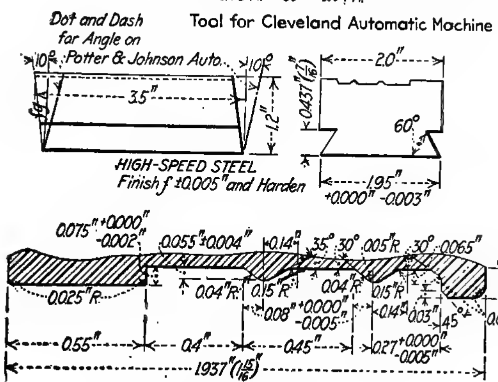
FIG. 25



Tool for Cleveland Automatic Machine

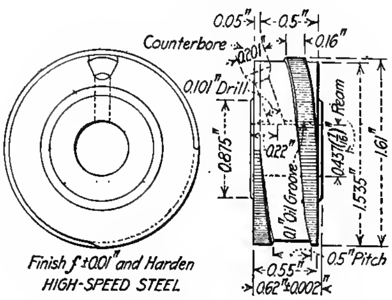


Detail of Knurls



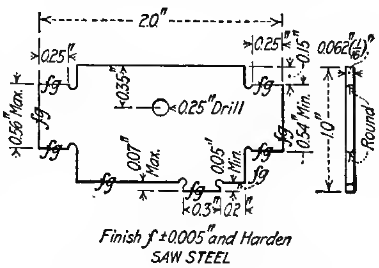
Tool for Potter & Johnson Automatic

FIG. 23



Knurling Tool

FIG. 24



Band Seat Width and Depth

FIG. 26

OPERATION 3

The forgings shall be free cutting and readily machined. The machinability will be determined by turning the body of the forgings, as received, from the drawing diameter to a diameter of 3.062 in. on an engine lathe. This turning will be done at an average rate of 14 shells per hour per lathe, and at this speed the tool consumption shall not exceed one tool for each 20 shells turned at this rate.

For the purpose of the test for physical qualities and for phosphorus and sulphur content the forgings will be separated into lots of 2000 each. From each lot of 2000 the inspector will select six forgings for physical test, provided that additional forgings may be selected, if necessary, to obtain not less than one forging from each lot of forgings as heat-treated. Two specimens for physical test will be taken from each sample forging from such parts of the forging as, in the judgment of the inspector, will best indicate the uniformity of physical qualities throughout. The contractor shall furnish the inspector with an analysis of each heat of steel used, which may be verified by the inspector if he so desires.

Forgings must be homogeneous in structure and free from pipes and cracks. Forgings in which these defects develop during machining will be replaced by the contractor. The interior of the forgings must be smooth and free from scale, and machining must be resorted to in order to produce this result, in case smoothness is not obtained by forging under the press.

A finished shrapnel case with all dimensions is illustrated in Fig. 2, and a completely assembled projectile is shown in Fig. 3. This last weighs approximately 15 lb., divided as follows:

	Lb.		Lb.
Case	5.89	Balls (238)	5.71
Band	0.15	Matrix	0.43
Washer	0.02	Head filler	0.07
Head	0.7	Diaphragm	0.48
Retainer	0.01	Base charge	0.17
Tube (including inner tube)	0.09	Fuse	1.28
		Total weight	15 ±0.15

The efficiency equals 38 per cent., and the velocity of the balls must be not less than 260 ft. per sec.

The night tracer referred to is a small device placed on 10 per cent. of the projectiles, for use at night. As the shell is fired, the tracer leaves a trail of fire behind it, commencing a few seconds after it leaves the muzzle of the gun and making it possible to follow the flight easily. This device will be described in detail elsewhere.

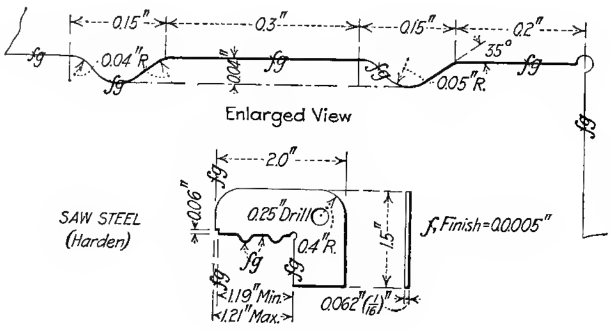
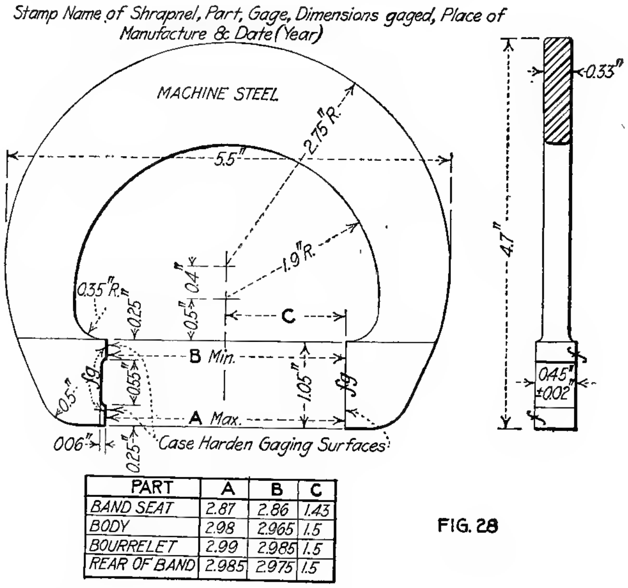


FIG. 27



PART	A	B	C
BAND SEAT	2.87	2.86	1.43
BODY	2.98	2.965	1.5
BOURRELET	2.99	2.985	1.5
REAR OF BAND	2.985	2.975	1.5

FIG. 28

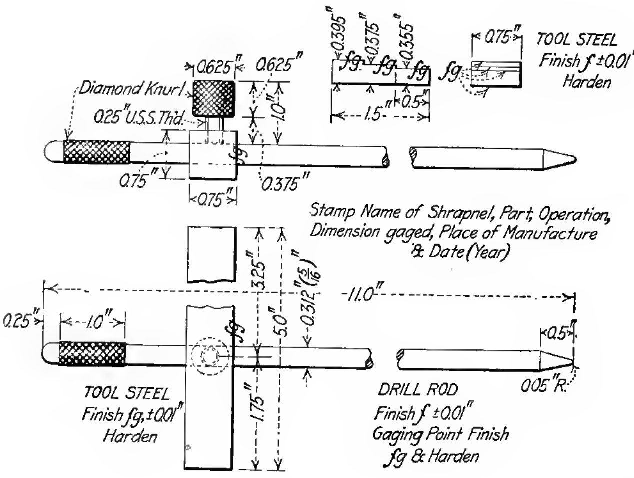


FIG. 29

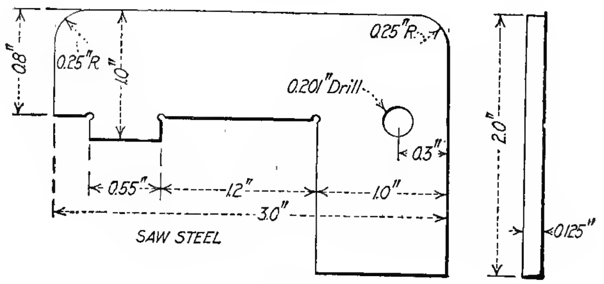


FIG. 30

OPERATION 3

The sequence of operations from the centering of the case forging to the final crimping on of the waterproof cover is as follows:

1. Centering
2. Turn body
3. Finish outside (case without tracer support)
3-A. Finish outside (case with tracer support)
4. Finish interior (and bourrelet when cases are finished at Frankford Arsenal)
5. Assemble band
6. Hydraulic test
7. Turn bands
8. Tap for night tracer

Head (Bar Stock)

1. Machine without thread and countersink
2. Countersink
3. Turn threads
9. Mill notches
4. Crimp in washer
5. Wash in hot soda water
6. Paint inside
7. Insert retainer and fill with resin
8. Face off resin

Diaphragm (Forging)

1. Drill and counterbore
2. Heat-treatment
3. Remove scale from counterbore
4. Grind base
5. Paint base
6. Assemble tube

Locking Pins (Bar Stock)

1. Machine

Assembling

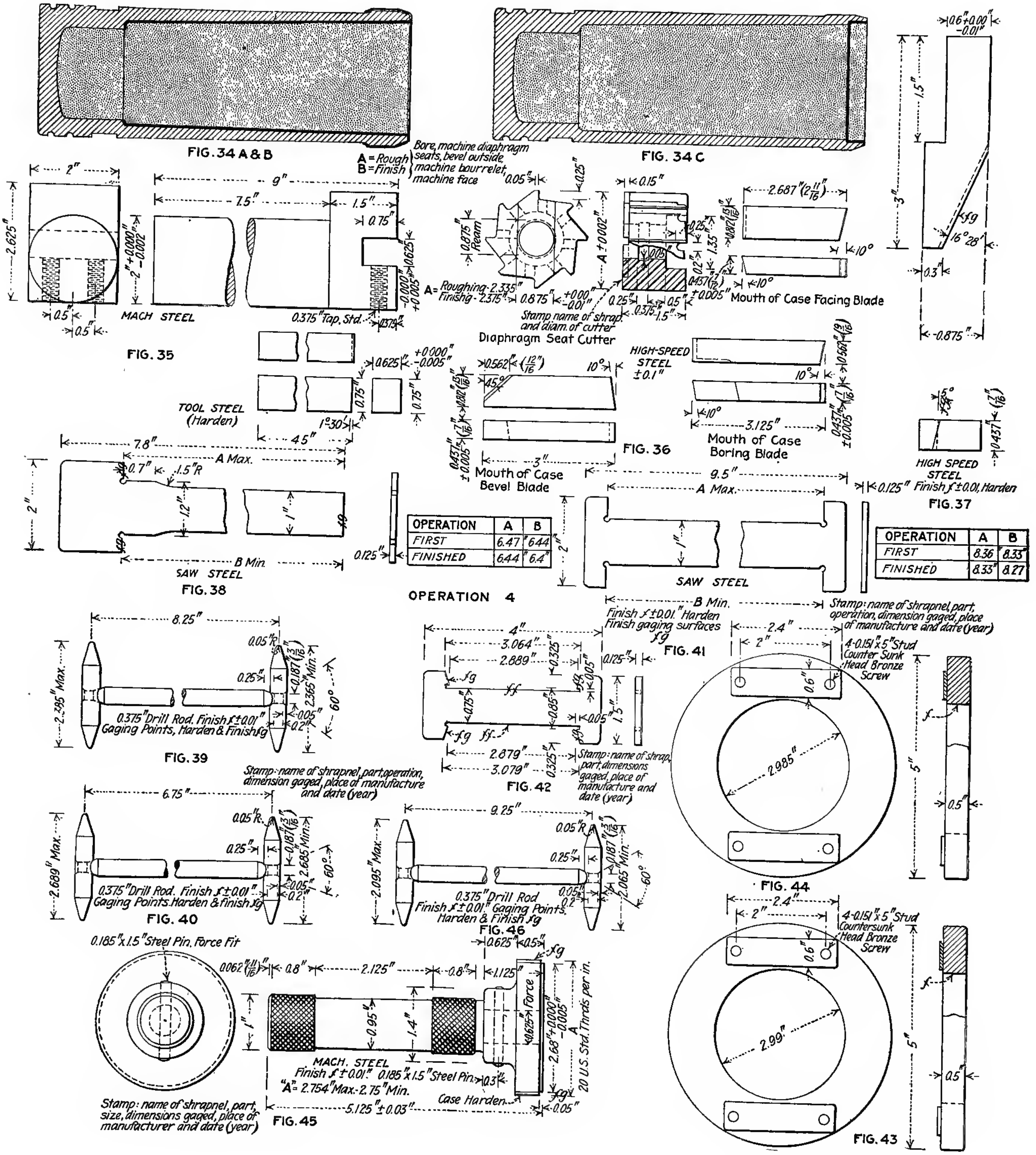
1. Wash case in hot soda water
2. Paint interior

3-A. Assemble tube and diaphragm

3-B. Fill case

3-C. Compress balls

4. Cut out surplus resin
5. Moisten threads with cosmoline, assemble head to case and insert inner tube
6. Pin head to case



OPERATION	A	B
FIRST	6.47"	6.44"
FINISHED	6.44"	6.4"

OPERATION	A	B
FIRST	8.36	8.33"
FINISHED	8.33"	8.27

FIG. 34 A & B. FIG. 34 C. FIG. 35. FIG. 36. FIG. 37. FIG. 38. FIG. 39. FIG. 40. FIG. 41. FIG. 42. FIG. 43. FIG. 44. FIG. 45. FIG. 46.

Tube (Central)

1. Machine

Tube (Inner)

1. Machine

Retainer

1. Machine

Washer (Sheet Steel)

1. Punch

Making Balls

1. Casting ingots
2. Extruding the wire
3. Forming balls on special machine

3-A. Forming balls on punch press

7. Turn bourrelet (when cases are finished by outside contract)
8. Groove for waterproof cover
9. Paint outside
10. Load powder charge
11. Brush cosmoline on fuse threads
12. Screw in fuse and lock
13. Set fuse to safety point
14. Crimp on waterproof cover

The centering is a simple operation. Following this is the turning of the body, Fig. 5. The outside finishing,

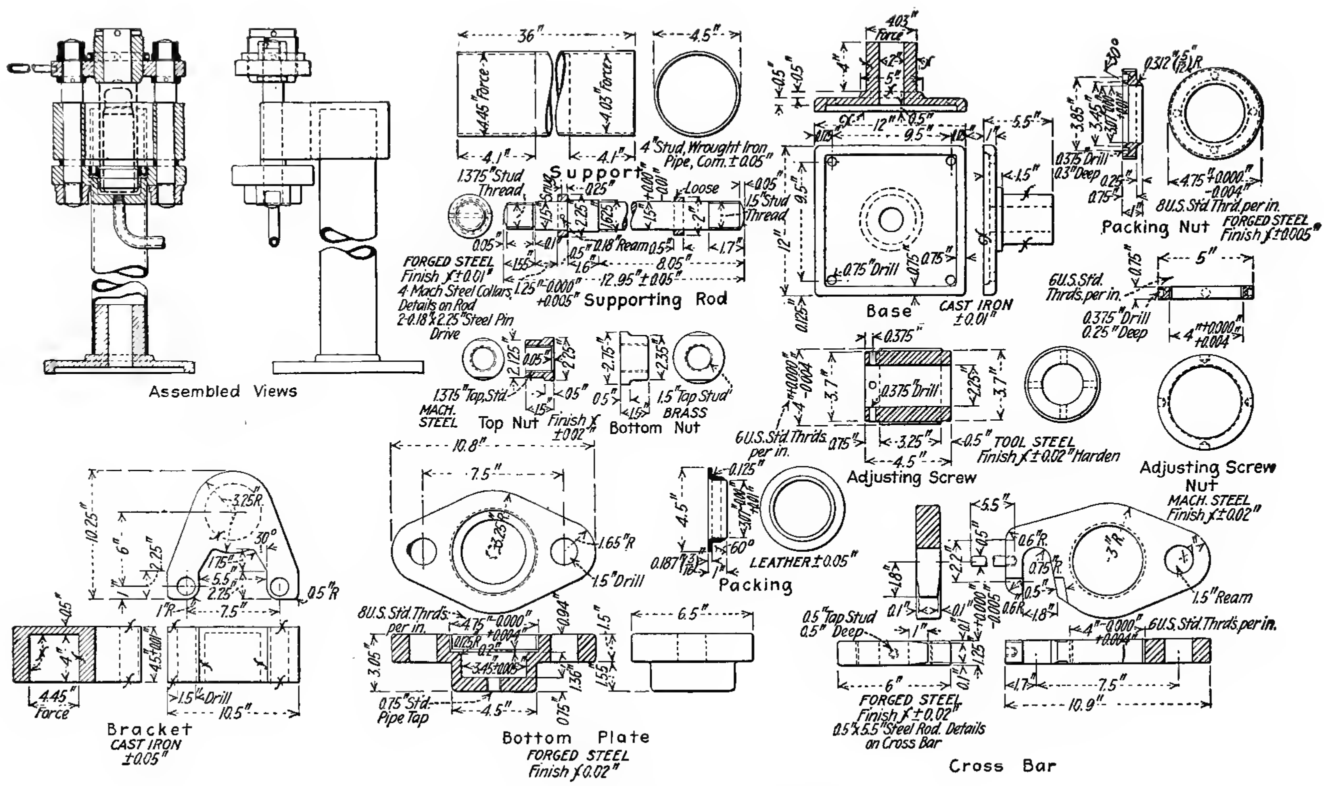


FIG. 47

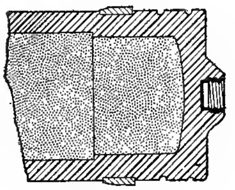


FIG. 50

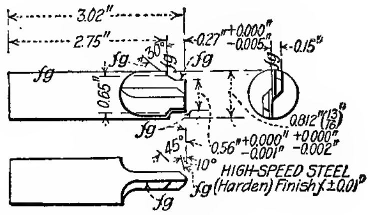


FIG. 53

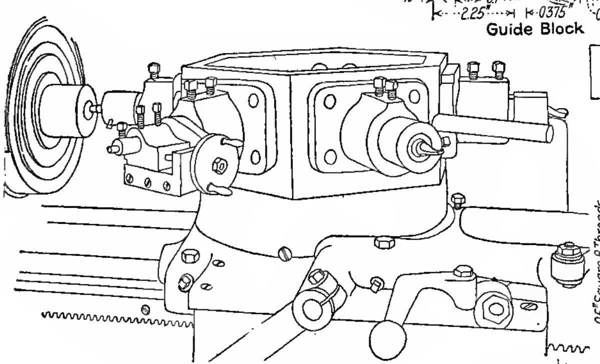
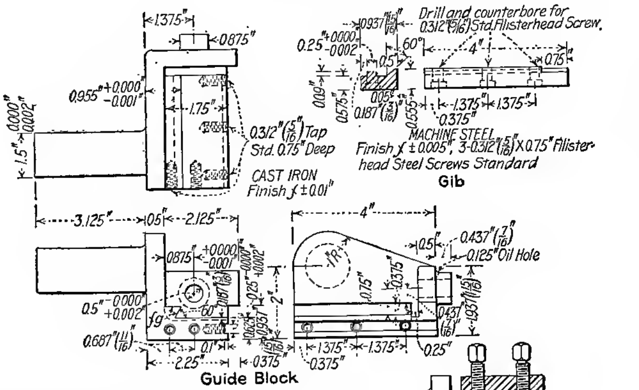


FIG. 51



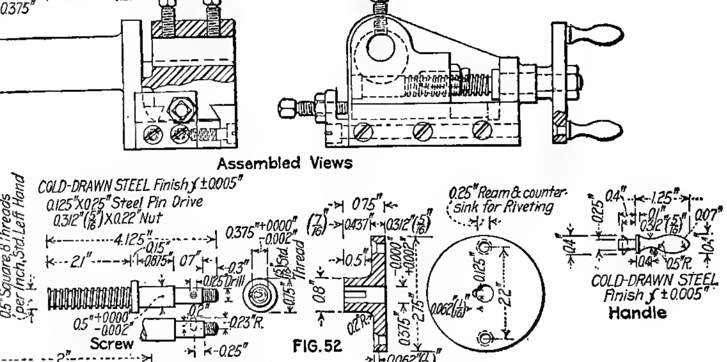


FIG. 52

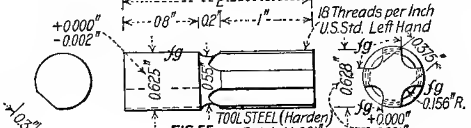


FIG. 55

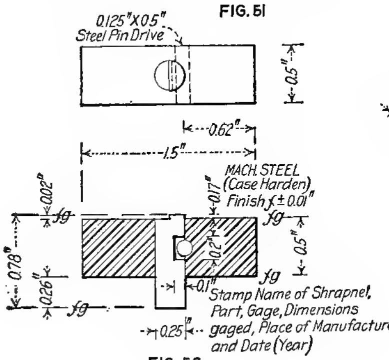


FIG. 56

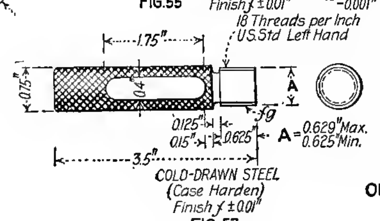
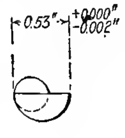


FIG. 57



OPERATION 8

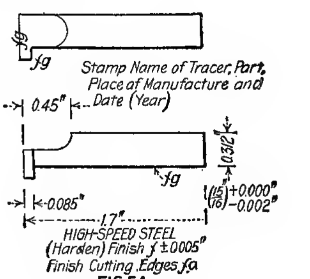
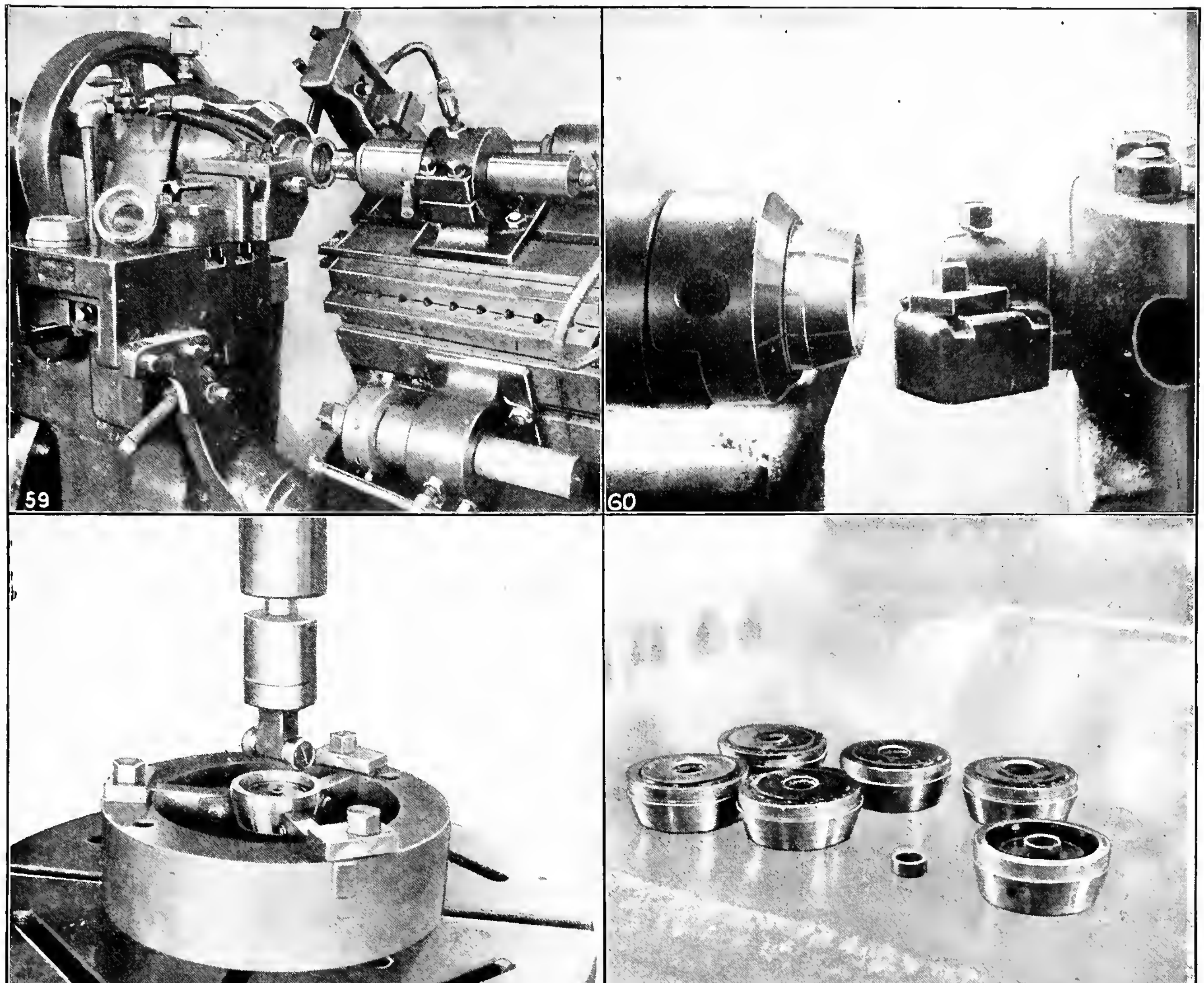


FIG. 54



FIGS. 59 TO 64. VARIOUS OPERATIONS ON THE HEAD

Fig. 59—Machining the head. Fig. 60—Countersinking head. Fig. 61—Crimping in washer. Fig. 62—Inserting retainer and filling with resin. Fig. 63—Facing off resin. Fig. 64—Notching head

shown in Figs. 6 and 7, differs principally in that in the latter case a larger place has to be left on the end for the tracer support, a special tool being used. Finishing the interior, Fig. 8, is done on both Potter & Johnston and Cleveland machines, as shop conditions at the time or as the sizes of the various shells dictate.

The method of assembling and turning the copper rotating bands is described in the article on the 3-in. common steel, or high-explosive, shell. The making of the band is also described in the article.

Standard cutting tools, which are used for all regular operations, are charted in Fig. 12 and will be designated

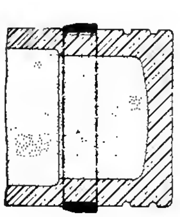
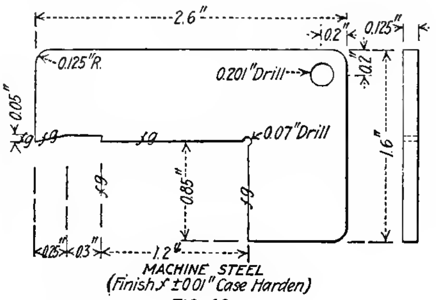


FIG. 48



MACHINE STEEL (Finish ƒ ±0.01" Case Harden)
FIG. 49

OPERATION 7

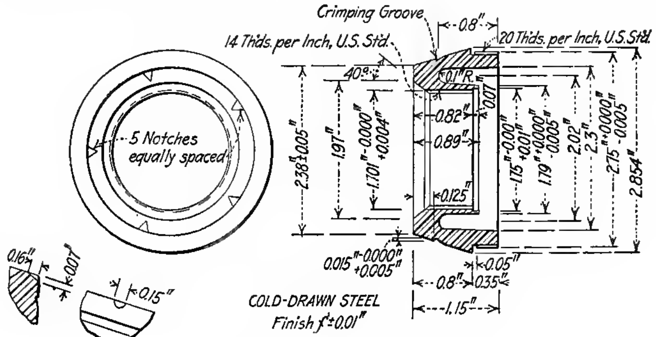


FIG. 58. DETAILS OF HEAD

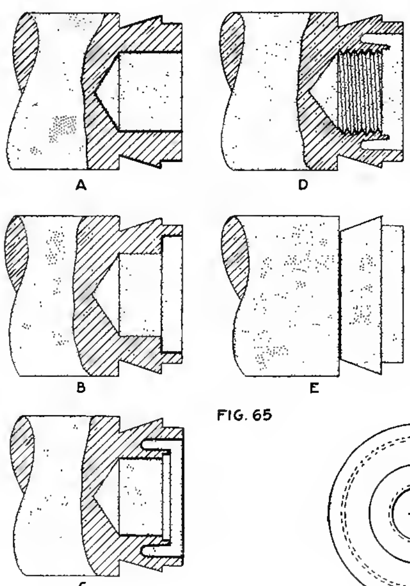


FIG. 65

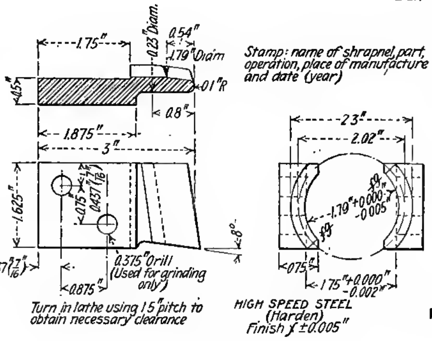


FIG. 70

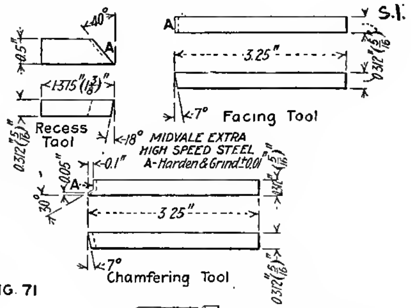


FIG. 71

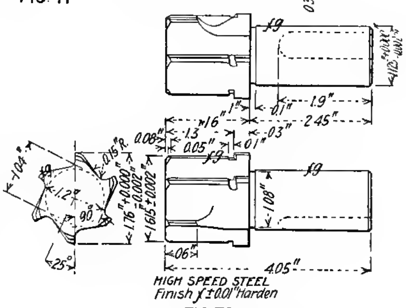


FIG. 72

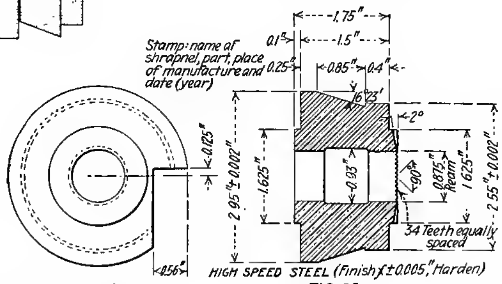


FIG. 66

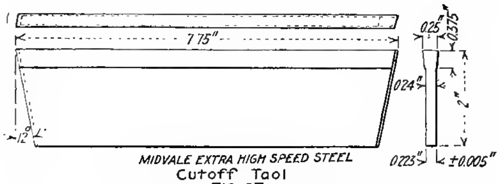


FIG. 67

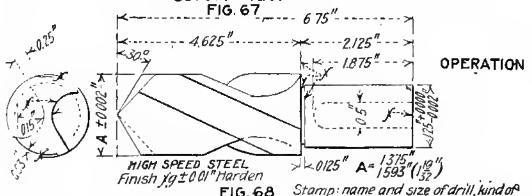


FIG. 68

OPERATION 1

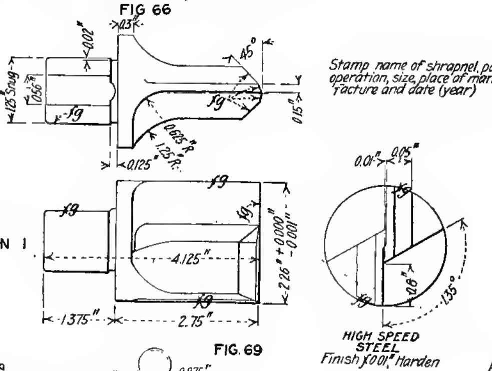


FIG. 69

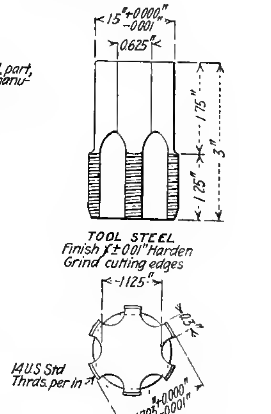


FIG. 73

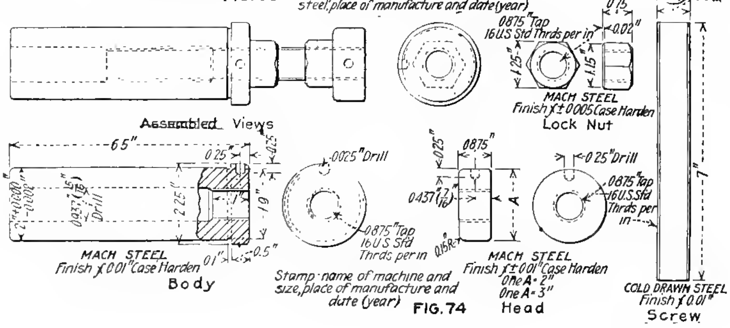


FIG. 74

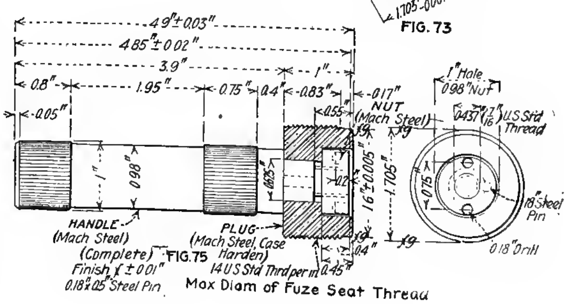


FIG. 75

individually only by their common names, such as left-hand lathe tool. The dimensions and shape of the various tools can be quickly obtained by reference to the chart.

Work on the Head

Details of the head are illustrated in Fig. 58. This is machined from bar stock on automatic machines, as shown in Fig. 59, each operator tending three machines. The end of the bar is drilled, bored, counterbored, reamed, grooved, faced and tapped for the fuse. At the same time the outside is formed with a circle tool. The tap used is of the collapsing type, oil being forced to the work from the rear. As can be seen, ample provision is made for supplying all the tools with oil. Owing to the size of the piece, the number of operations and the accuracy

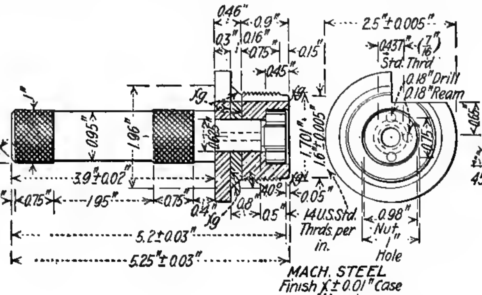
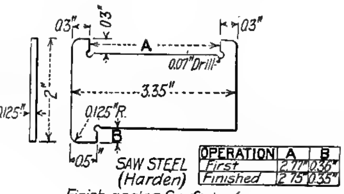


FIG. 76



OPERATION	A	B
First	2.77"	0.36"
Finished	2.75"	0.35"

FIG. 77

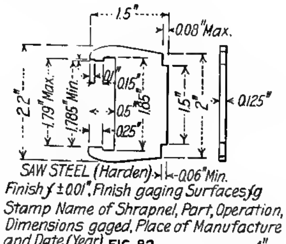


FIG. 82

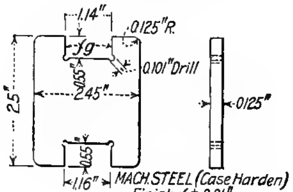
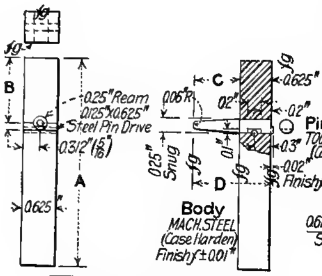


FIG. 78



HEAD	A	B	C	D
2.95-inch Shrapnel	4"	1"	0.69"	1.535"
3 " "	4"	1"	0.79"	1.435"
3.8 " "	4.5"	1.25"	1.11"	1.755"
4.7 " "	5"	1.25"	1.915"	2.56"
6 " "	6"	1.75"	2.64"	3.285"

FIG. 80

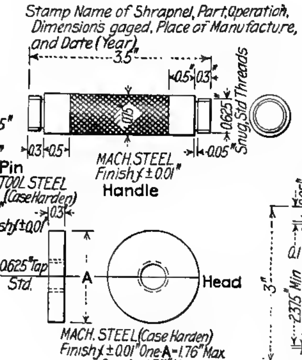


FIG. 81

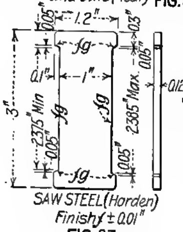


FIG. 83
OPERATION 1

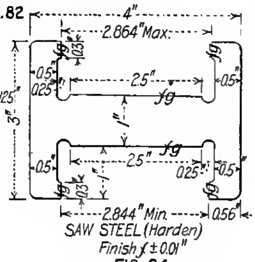


FIG. 84

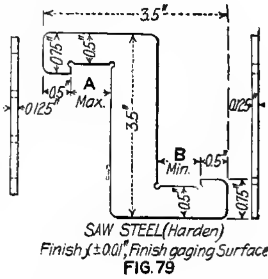


FIG. 79


FIG. 90

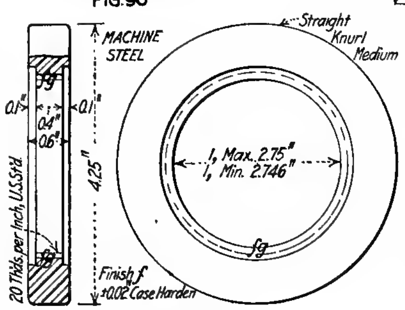


FIG. 93

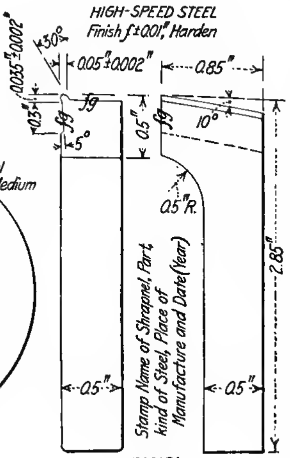


FIG. 91

needed, the rate of production is here comparatively low. After the machined head is severed from the bar, it is placed in a special chuck, Fig. 86, on a turret lathe, and the mouth is countersunk with a beveling tool carried in the turret, as shown in Fig. 60. The thread for holding the head to the case is chased on in a turret lathe.

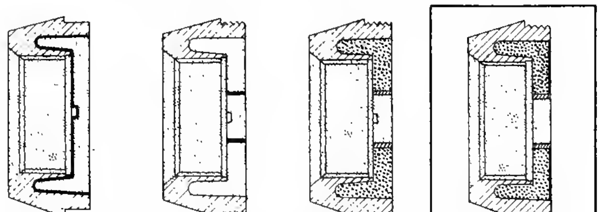


FIG. 98
OPERATION 6

FIG. 99
OPERATION 7

FIG. 100

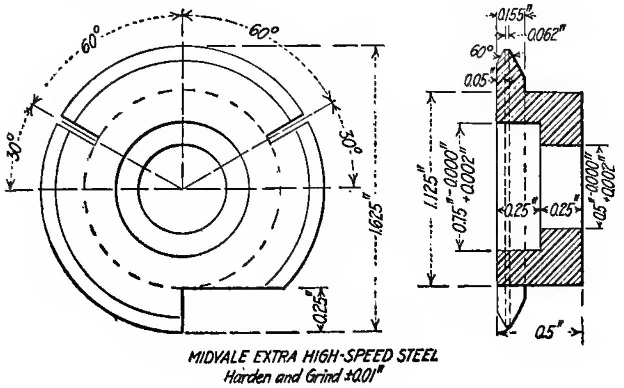


FIG. 92

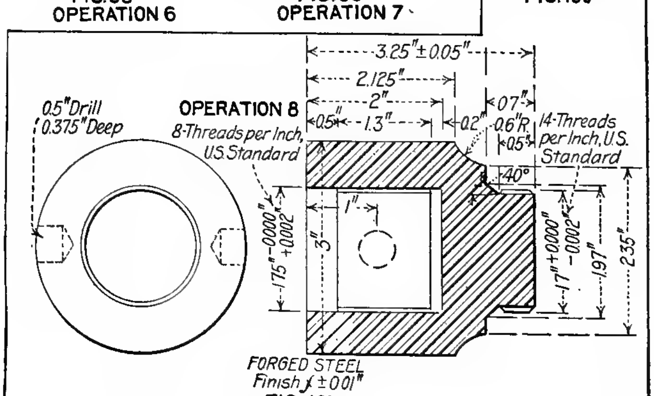


FIG. 101

The washer is made of thin sheet metal and is placed in the head, and the edges are crimped down into the grooves of the head with a double roller tool, as shown in Fig. 60, details of the tool being given in Fig. 96.

After the head has been thoroughly washed in hot soda water, the inside is painted by hand; then the short piece of tube, or retainer, is put in place and melted resin is poured in, as shown in Fig. 62. The resin is allowed to cool, and then the head is placed in a special screw chuck and the resin faced off, as shown in Fig. 63, details of the chuck being given in Fig. 101. The tool used is a standard left-hand facing tool.

The purpose of milling notches in the head is to provide means for locking the fuse securely after it is screwed into the mouth of the case, metal on the fuse being forced into these notches with a punch and hammer. The notch milling is illustrated in Fig. 64, the fixture being a rather simple one, but answering the purpose perfectly.

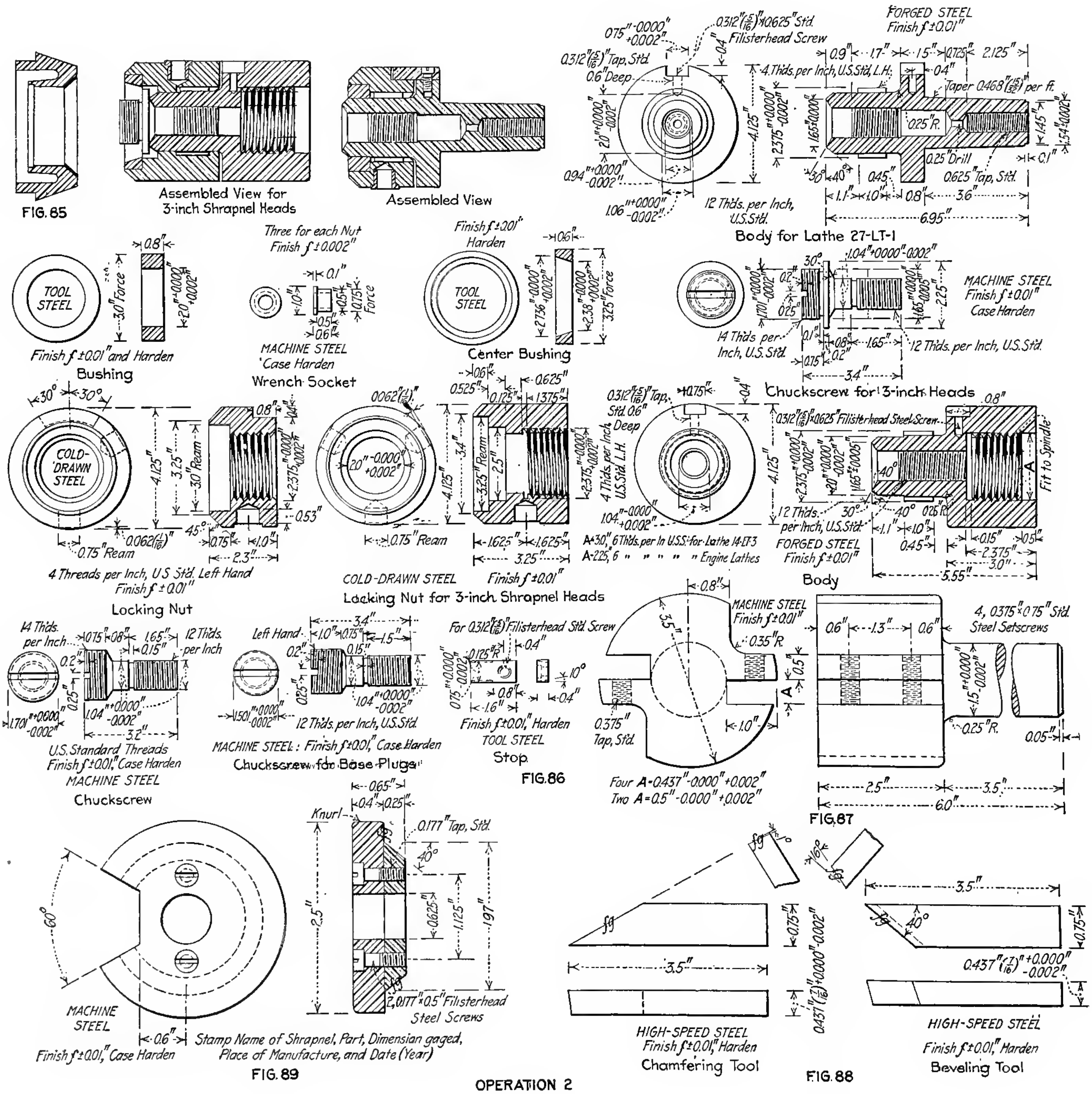
Head (Bar Stock)

OPERATION 1. MACHINE WITHOUT THREAD AND COUNTERSINK

Transformation—Fig. 65. Machine Used—Gridley or Cleveland automatic, Fig. 59. Number of Machines per Operator—Three. Work-Holding Devices—Split chuck. Tool-Holding Devices—Circular form-tool holder, cutoff-tool holder, drill holder, rough-tool holder, combination groove-tool and reamer holder, tap holder and adapter. Cutting Tools—Circular form tool, Fig. 66; cutoff tool, Fig. 67; twist drill, Fig. 68; roughing tool, Fig. 69; set (2) grooving tools, Fig. 70; facing tool, Fig. 71; combination counterbore and reamer, Fig. 72; tap, Fig. 73 Cut Data—50 ft. surface speed. Coolant—Zurn oil. Special Fixtures—Stop, Fig. 74. Gages—Maximum thread, plug, Fig. 75; minimum thread, plug, Fig. 76; diameter and length of thread (operation 1), Fig. 77; length over all, Fig. 78; length of shoulder (operation 1), Fig. 79; depth of groove, Fig. 80; maximum and minimum inner diameter of crimp wall, Fig. 81; outer diameter and depth of crimp wall, Fig. 82; diameter of small end, Fig. 83; diameter of large end, Fig. 84. Production—115 per 8 hr.

OPERATION 2. COUNTERSINK

Transformation—Fig. 85. Machine Used—Brown & Sharpe turret lathe, Fig. 60. Number of Operators per Machine—One. Work-Holding Devices—Special chuck, Fig. 86. Tool-Holding Devices—Tool holder, Fig. 87. Cutting Tools—Beveling tool, Fig. 88. Cut Data—210 r.p.m. Gages—Diameter of fuse-seat bevel, Fig. 89; minimum diameter of fuse seat and fuse-seat thread, Fig. 76. Production—800 per 8 hr.



OPERATION 2

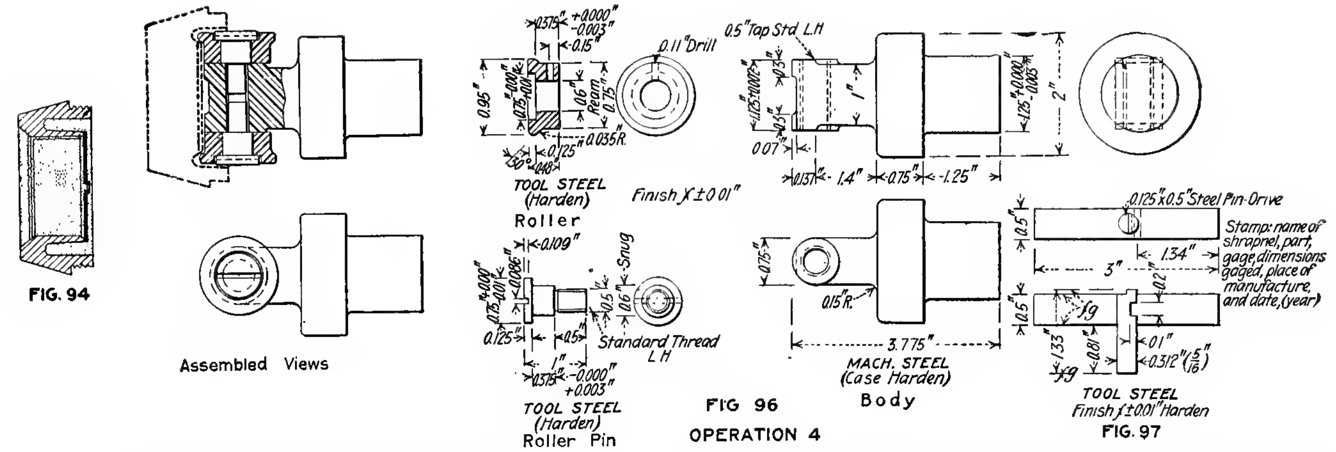


FIG. 94 FIG 96 OPERATION 4 FIG. 97

OPERATION 3. TURN THREAD

Transformation—Fig. 90. Machine Used—Brown & Sharpe turret lathe. Number of Operators per Machine—One. Work-Holding Devices—Special chuck, Fig. 86. Tool-Holding Devices—Chamfering-tool holder, holder for circular thread cutter. Cutting Tools—Forming tool, Fig. 91; chamfering tool, Fig. 88; circular thread cutter, Fig. 92. Cut Data—200 ft. surface speed. Coolant—Lard oil, put on with brush. Gages—Maximum thread, ring, Fig. 93; minimum thread, ring, Fig. 93; diameter length of finished thread, Fig. 77; maximum and minimum length of shoulder, Fig. 79. Production—250 per 8 hr. Note—This is a thread-chasing operation, as can be seen from the illustration.

OPERATION 9. MILL NOTCHES

Transformation—Fig. 102. Machine Used—Brown & Sharpe miller, Fig. 64. Number of Operators per Machine—One. Tool-Holding Devices—Arbor, Fig. 103. Cutting Tools—Milling cutter. Cut Data—Cutter runs 370 r.p.m. Special Fixtures—Fig. 104. Production—1400 per 8 hr.

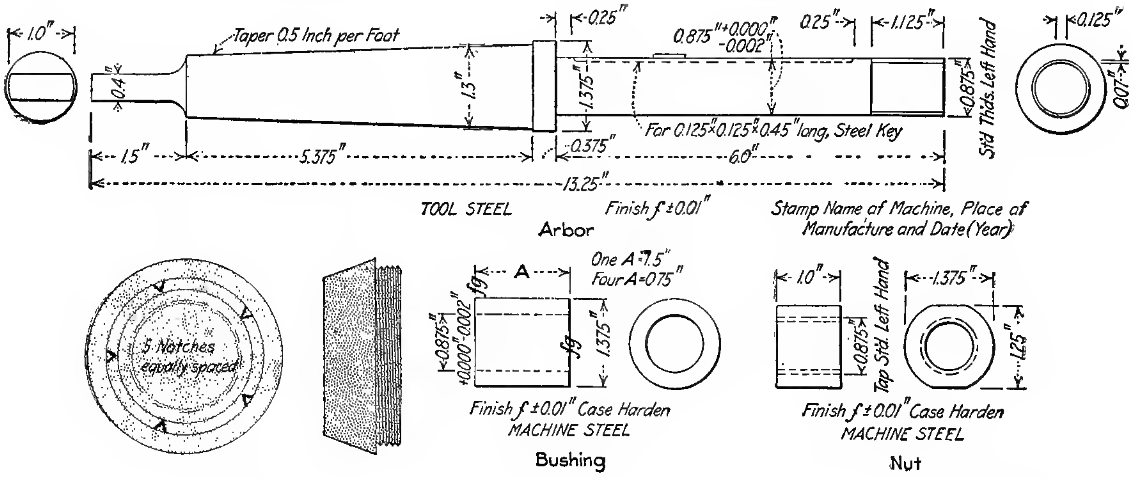


FIG. 102 FIG. 103

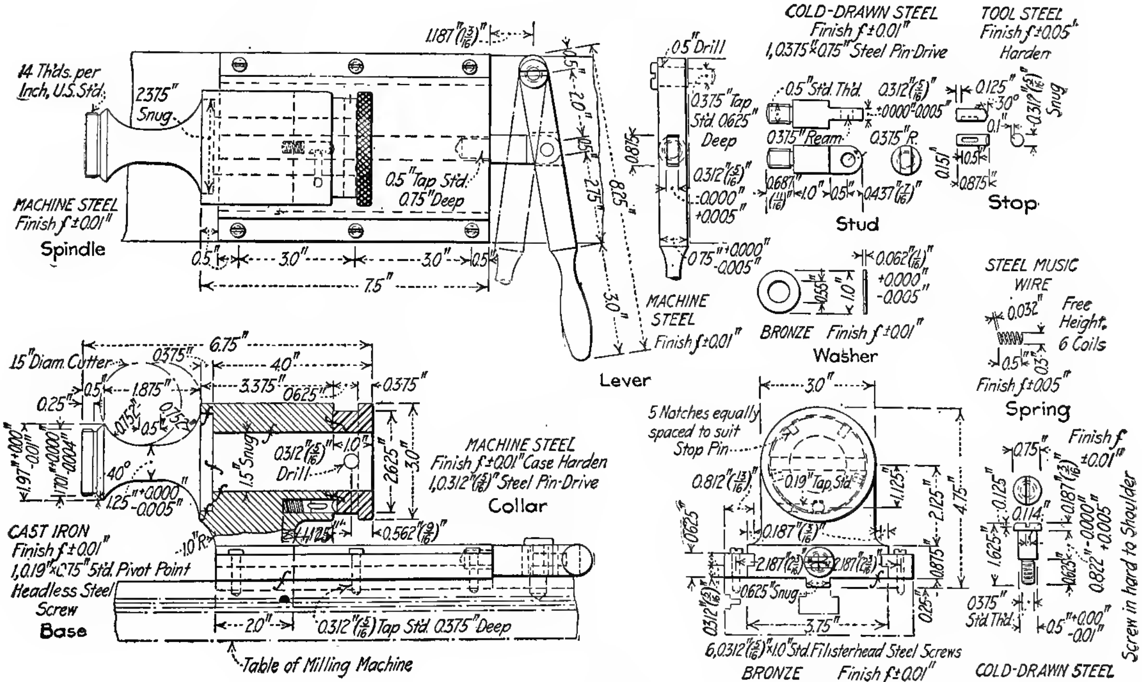


FIG. 104
OPERATION 9

OPERATION 4. CRIMP IN WASHER

Transformation—Fig. 94. Machine Used—Drilling machine, Fig. 61. Number of Operators per Machine—One. Work-Holding Devices—Special chuck. Tool-Holding Devices—Crimping-tool holder. Tools—Crimping tool, Fig. 96. Cut Data—260 r.p.m. Gages—Depth of disk, Fig. 97. Production—1400 per 8 hr.

OPERATION 5. WASH IN HOT SODA WATER

Number of Operators—One. Description of Operation—Operator puts 40 heads into a dipping basket and sets it in cleaning solution; when grease is off, the heads are rinsed in hot water; if not too greasy, about 2 min. is enough time for cleaning. Apparatus and Equipment Used—One tank of boiling Wyandotte metal-cleaner solution; one tank of boiling water; metal dipping baskets. Production—2500 per day.

OPERATION 6. PAINT INSIDE

Transformation—Fig. 98. Number of Operators—One. Apparatus and Equipment Used—Brush and pot of asphaltum varnish. Production—1200 per day.

OPERATION 7. INSERT RETAINER AND FILL WITH RESIN

Transformation—Fig. 99. Description of Operation—Operator places head, small end down, on plate, then puts in retainer and pours in melted resin, Fig. 62. Apparatus and Equipment Used—Metal plate, furnace and kettle, pouring ladle. Production—1200 per 8 hr.

OPERATION 8. FACE OFF RESIN

Transformation—Fig. 100. Machine Used—Small lathe, Fig. 63. Number of Operators per Machine—One. Work-Holding Devices—Special screw chuck, Fig. 101. Cutting Tools—Left-hand facing tool. Cut Data—220 r.p.m. Production—1200 per 8 hr.

Diaphragm (Forging)

OPERATION 1. DRILL AND COUNTERBORE

Transformation—Fig. 106. Machine Used—Turret lathe. Number of Operators per Machine—One. Work-Holding Devices—Special screw chuck, Fig. 107. Tool-Holding Devices—Drill holder and bushing, countersink holder and bushing, counterbore holder and bushing. Cutting Tools—Twist drill; countersink, Fig. 108; counterbore, Fig. 109. Gages—Maximum diameter, ring, Fig. 110; minimum diameter, ring, Fig. 111; maximum and minimum diameter counterbore, plug, Fig. 112; depth of counterbore, Fig. 113. Production—400 per 8 hr. Note—These are forgings, trimmed outside in a die, and only have to be drilled and counterbored.

OPERATION 2. HEAT-TREATMENT

Number of Operators—One. Description of Operation—Diaphragms are kept in furnace until temperature reaches 1600 deg. F., then taken out and placed in cottonseed-oil bath to harden; next, are rumbled in hot soda water to remove scale, and are then drawn to 900 deg. F. in saltpeter bath. Apparatus and Equipment Used—Furnace; perforated copper basket, 24 in. long, 15 in. wide, 12 in. deep; rumbling device. Production—4800 per 8 hr.

OPERATION 3. REMOVE SCALE FROM COUNTERBORE

Machine Used—Drilling machine. Tool-Holding Devices—Drill chuck. Cutting Tools—Twist drill, ground to suit. Production—1400 per 8 hr.

OPERATION 4. GRIND BASE

Transformation—Fig. 114. Machine Used—Diamond-disk grinder, Fig. 115. Number of Operators per Machine—One. Note—Operator holds piece on disk until a flat seat is ground on the bottom; one operator generally grinds, paints and assembles with a total of from 800 to 1000 per day.

OPERATION 5. PAINT BASE

Transformation—Fig. 116. Description of Operation—Operator applies asphaltum varnish to base with a brush. Production—See grinding note.

OPERATION 6. ASSEMBLE TUBE

Transformation—Fig. 117. Description of Operation—Operator presses tube into diaphragm, as shown in Fig. 118. Apparatus and Equipment Used—Fixture, Fig. 119. Gages—Length, Figs. 120 and 121. Production—See grinding note.

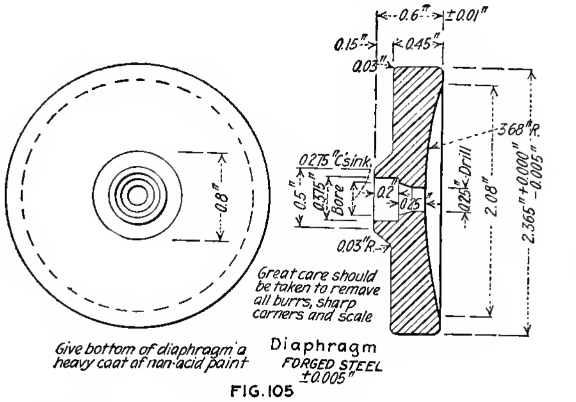


FIG. 105

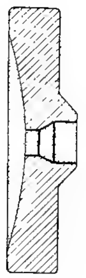


FIG. 106

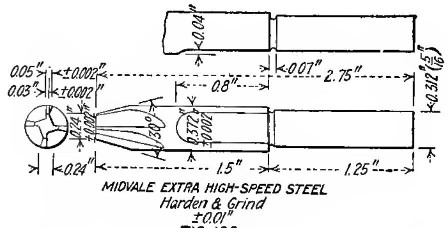


FIG. 108

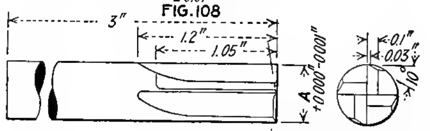


FIG. 109

SIZE	A
2.95"	0.375"
3"	0.375"
3.8"	0.5"
4.7"	0.5"
6"	0.5"

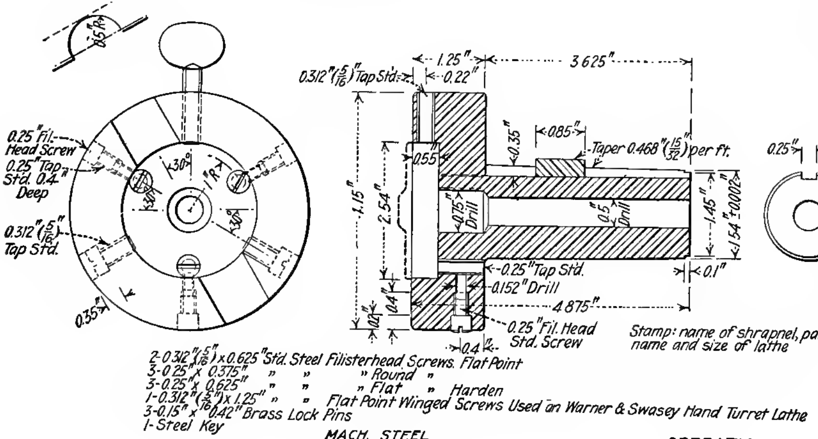


FIG. 107

OPERATION 1

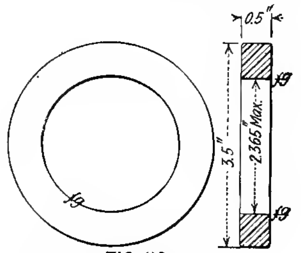


FIG. 110

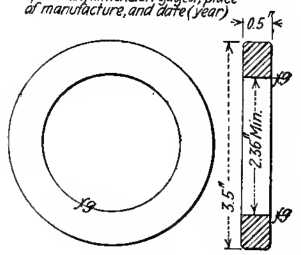


FIG. 111

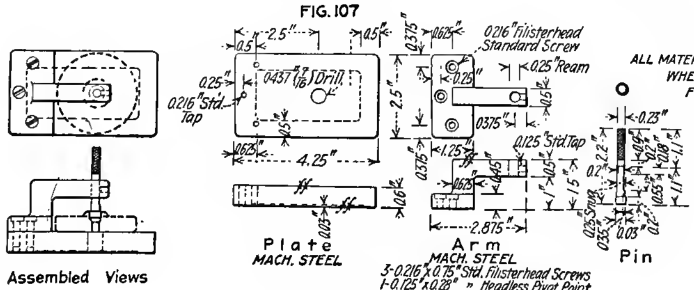


FIG. 113

SIZE	A	B
2.95"	0.375"	0.373"
3"	0.375"	0.373"
3.8"	0.5"	0.498"
4.7"	0.5"	0.498"
6"	0.5"	0.498"

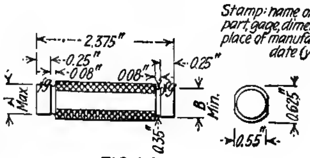


FIG. 112

Locking Pins

OPERATION 1. MACHINE (BAR STOCK)

Transformation—Fig. 122. Machine Used—Brown & Sharpe automatic. Number of Machines per Operator—Three. Cutting Tools—Cutoff and form tool, Fig. 123. Coolant—Zurn oil. Gages—Length, Fig. 124. Production—2500 per 8 hr.

Work on the Diaphragm

Since a diaphragm is forged and then trimmed in a die, the amount of machining work needed is small. It is held in a special chuck, Fig. 107, in a turret lathe and drilled and counterbored. Following the heat-treatment, which is given in detail under the proper heading, the base is ground on a disk grinder in order that it may seat properly in the case. Removing scale from the counterbore is simply a scraping operation, and an old twist drill, ground to suit, is used in a drilling machine. The base is next painted, and the center tube is pressed in with the special fixture, Fig. 119. The work on locking pins, central tubes, inner tubes and retainers is all simple.

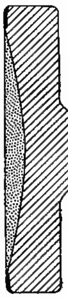


FIG. 114

OPERATION 4

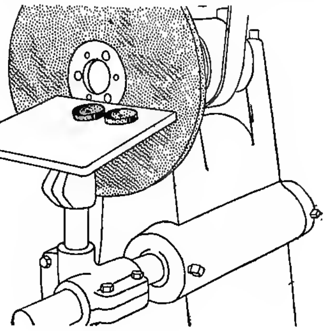


FIG. 115

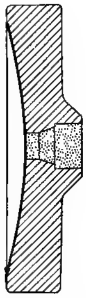
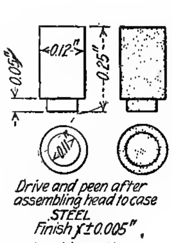


FIG. 116, OP. 5



Locking Pin

FIG. 122

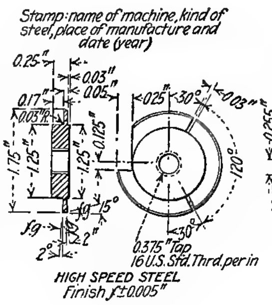


FIG. 123

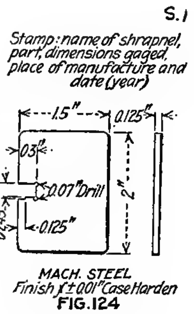


FIG. 124

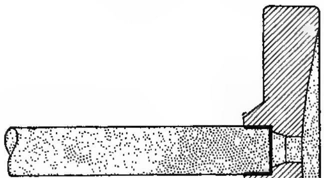


FIG. 117

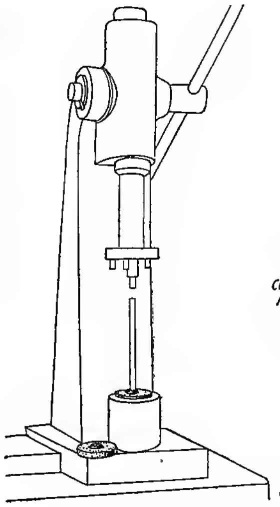


FIG. 118

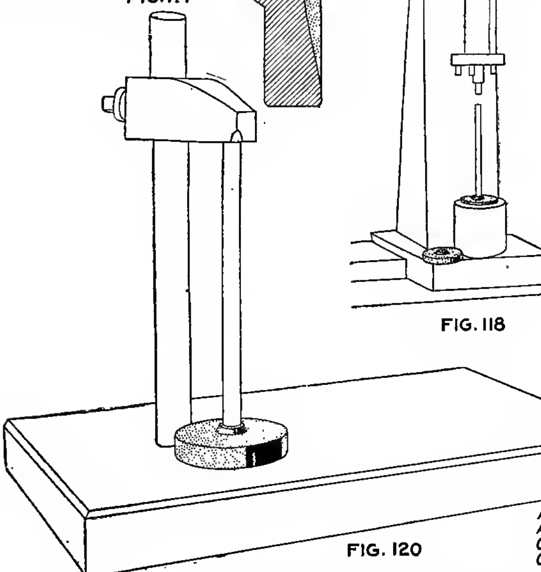


FIG. 120

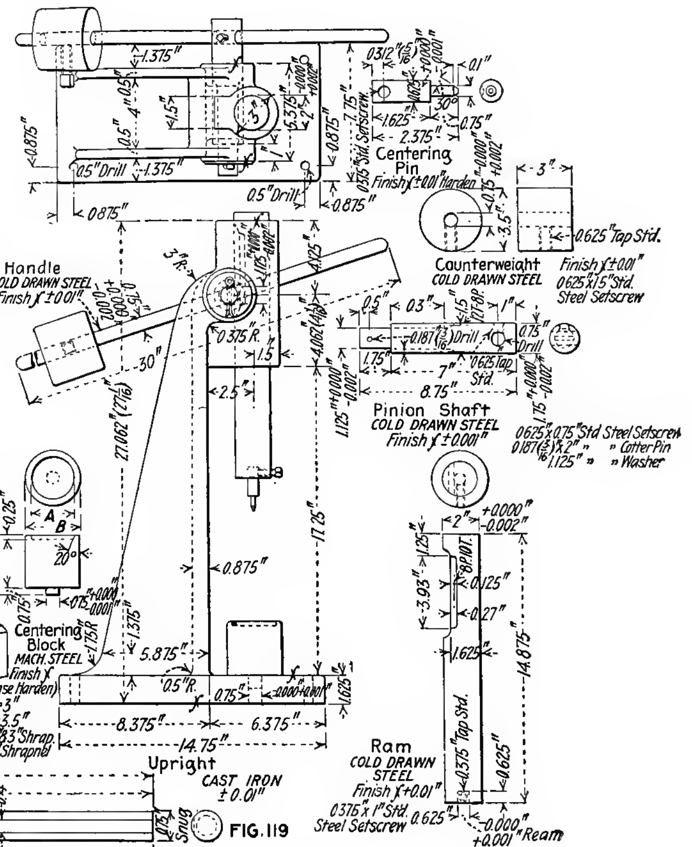


FIG. 119

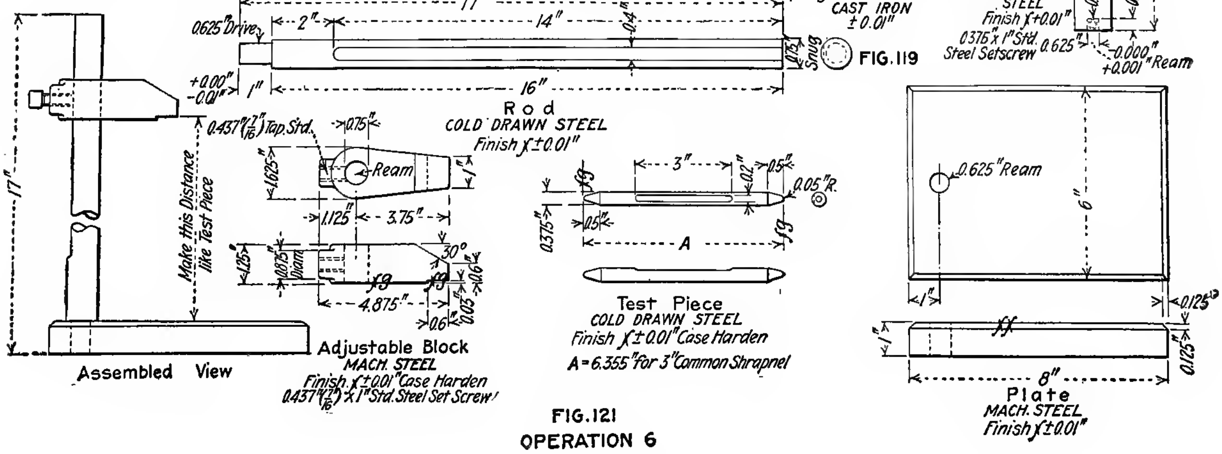


FIG. 121

OPERATION 6

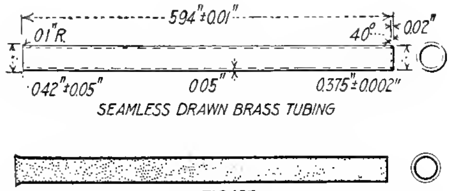


FIG. 125

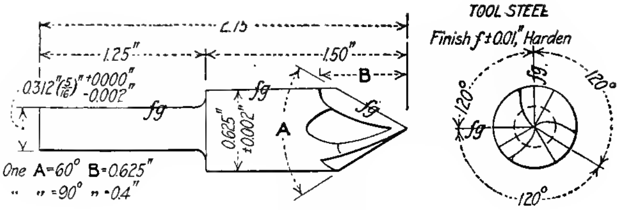


FIG. 126

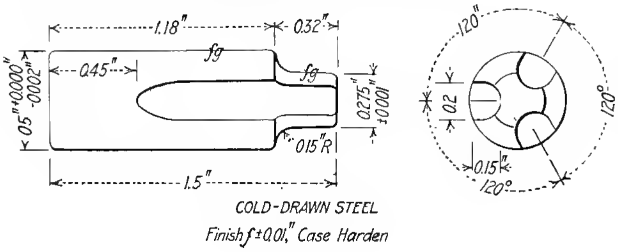


FIG. 127

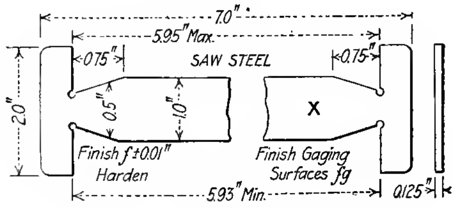


FIG. 129

X=Stamp Name of Shrapnel, Part, Dimension gaged, Place of Manufacture and Date (Year)

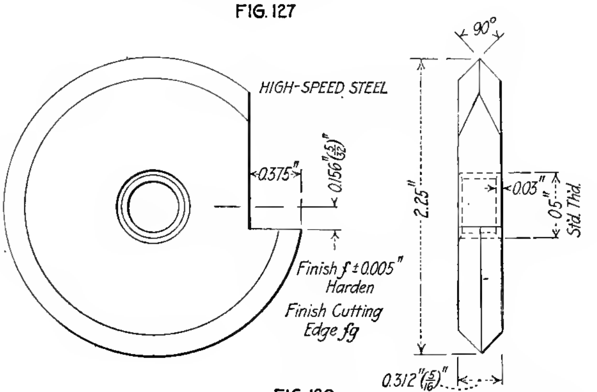


FIG. 128

OPERATION 1

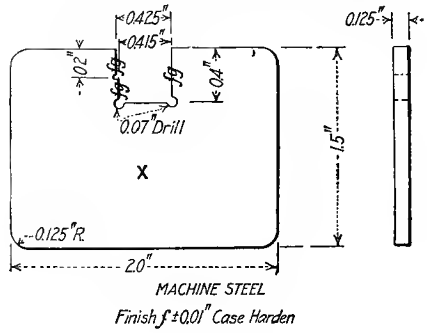


FIG. 130

Tube (Inner)

OPERATION 1. MACHINE

Transformation—Fig. 131. Machine Used—Brown & Sharpe automatic. Number of Machines per Operator—Three. Tool-Holding Devices—Four tool holders. Cutting Tools—Two countersinks, Fig. 126; two belling tools, Fig. 132; chamfering tool, Fig. 133; cutoff tool, Fig. 134. Cut Data—2400 r.p.m. Coolant—Lard oil. Gages—Overall length, Fig. 135; maximum and minimum diameter of bell, Fig. 135. Production—4200 per 8 hr. Note—Seamless copper tubing is used.

Tube (Central)

OPERATION 1. MACHINE

Transformation—Fig. 125. Machine Used—Brown & Sharpe automatic. Number of Machines per Operator—Three. Tool-Holding Devices—Four tool holders. Cutting Tools—Two countersinks, Fig. 126; two belling tools, Fig. 127; cutoff tool, chamfering tool, Fig. 128. Cut Data—2400 r.p.m. Coolant—Lard oil. Gages—Overall length, Fig. 129; maximum and minimum diameter of bell, Fig. 130. Production—2500 per 8 hr. Note—Seamless brass tubing is used.

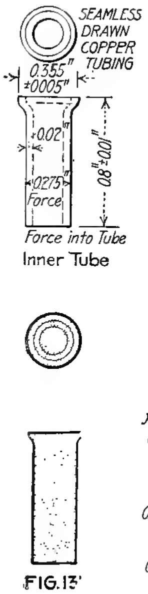


FIG. 131

Stamp Name of Shrapnel, Part, Size, Place of Manufacture and Date (Year)

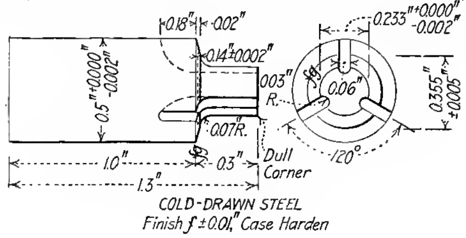


FIG. 132

Stamp Place of Manufacture and Date (Year)

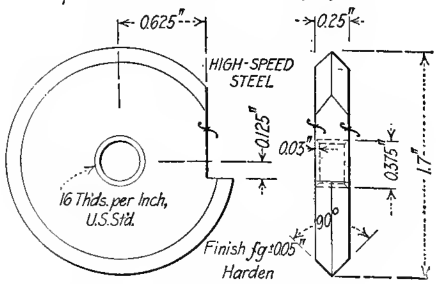


FIG. 133

Stamp Name of Machine, kind of Steel, Place of Manufacture and Date (Year)

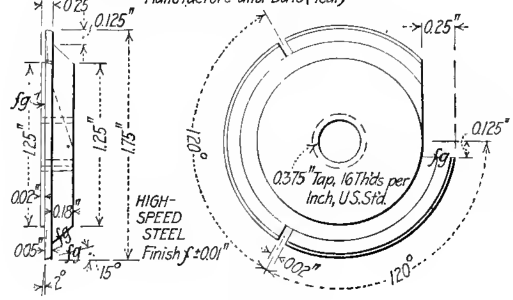


FIG. 134

Stamp Name of Shrapnel, Part, Dimensions gaged, Place of Manufacture and Date (Year)

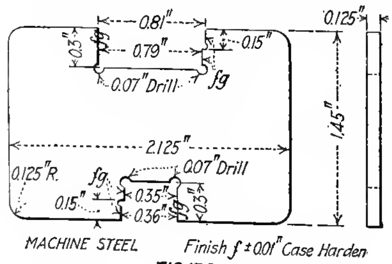


FIG. 135

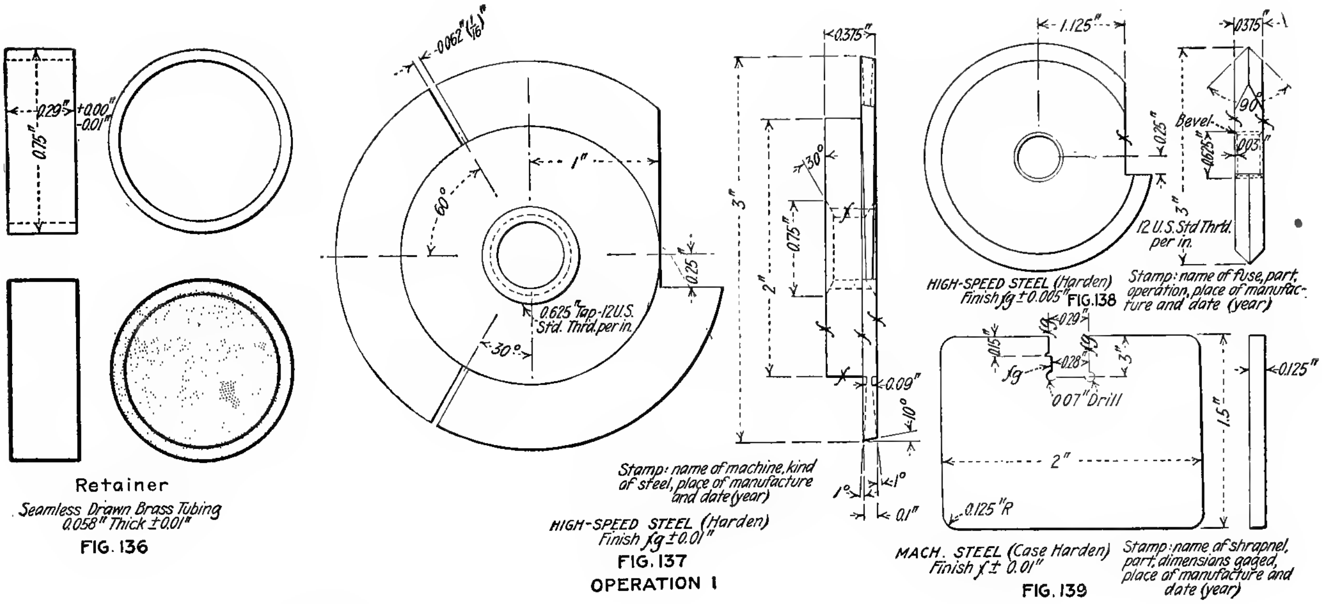


FIG. 136 FIG. 137 OPERATION 1 FIG. 138 FIG. 139

Retainer

OPERATION 1. MACHINE

Transformation—Fig. 136. Machine Used—Brown & Sharpe automatic. Number of Machines per Operator—Three. Cutting Tools—Cutoff tool, Fig. 137; chamfering tool, Fig. 138. Gages—Length, Fig. 139. Production—2500 per 8 hr. Note—Brass tubing used.

Washer

OPERATION 1. PUNCH (SHEET STEEL)

Transformation—Fig. 140. Machine Used—Crank press. Number of Operators per Machine—One. Punches and Punch Holders—Punch, Fig. 141. Dies and Die Holders—Die, Fig. 142. Lubricant—Machine oil. Production—8000 per 8 hr. Note—This completes the washer.

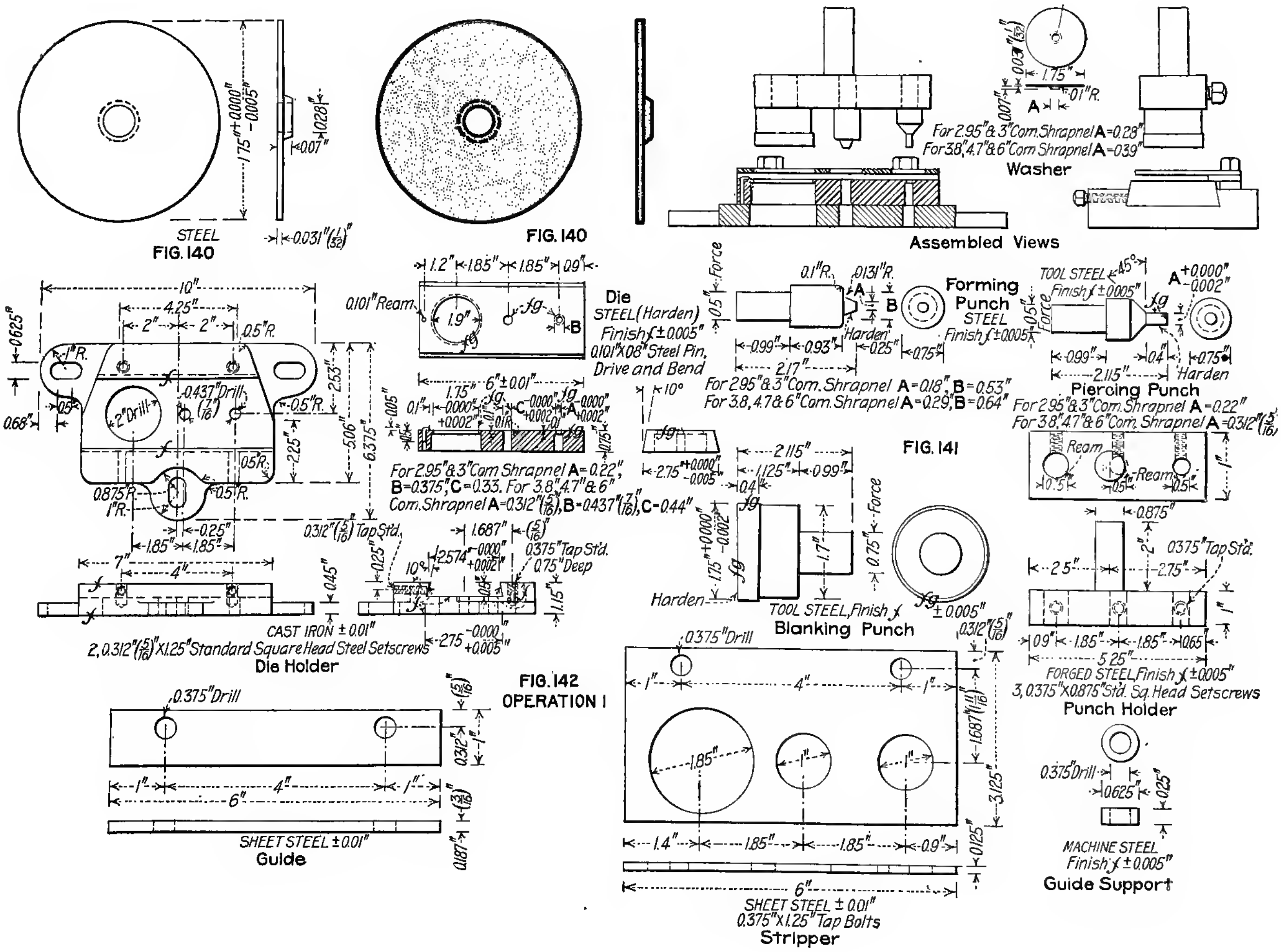
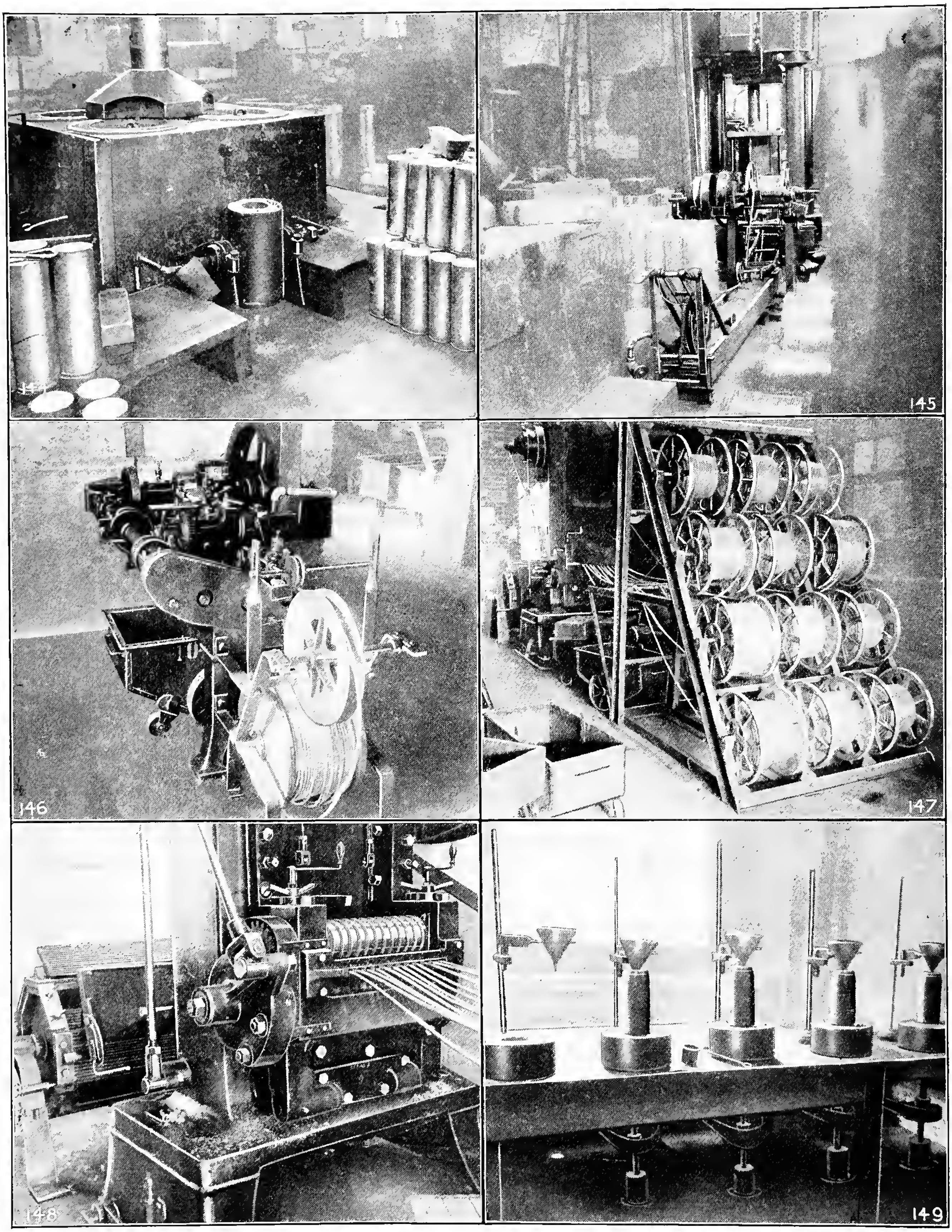


FIG. 142 OPERATION 1



FIGS. 144 TO 149. VARIOUS BULLET-MAKING AND POWDER-LOADING OPERATIONS

Fig. 144—Casting ingots. Fig. 145—Extruding the wire. Fig. 146—Special ball-forming machine. Fig. 147—Press and wire reels. Fig. 148—Roll feed and tumbler. Fig. 149—Powder-loading machines.

The lead balls used in shrapnel are both round and six-sided, as shown in Fig. 152, and are made in practically the same way, only different dies being used.

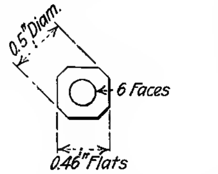
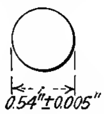
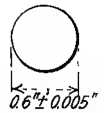
DIMENSIONS	SHRAPNEL SIZE	SHRAPNEL DRAWING NO.	PIECE MARK
	2.95"	75-2-41	41F
	3"	75-2-4	4F
	3"	75-2-137	137F
	3"	75-2-151	151G
	3"	75-2-152	75H
	3.8"	75-2-145	145B1
	4.7"	75-2-147	147A
	5"	F.A. 3574	
	6"	75-4-12	12C1
	6"	75-7-37	37C1
	7"	F.A. 3578	
COMPOSITION OF BALLS: 12.5% Antimony, 87.5% Lead			

FIG. 152. BALL DIMENSIONS

Making Balls

OPERATION 1. CASTING INGOTS

Transformation—Fig. 143. Number of Operators—One Description of Operation—Operator pours melted mixture of 7 parts lead and 1 part antimony into mold and allows it to cool for 3 or 4 min., then inverts mold and allows ingot to drop out, the shrinkage being sufficient for ample clearance. Apparatus and Equipment Used—Rockwell melting furnace, ladles, tongs and water-cooled mold, Fig. 144. Production—43 per day per mold.

OPERATION 2. EXTRUDING THE WIRE

Transformation—Fig. 150. Machine Used—Waterbury-Farrel 700-ton hydraulic press, Fig. 145. Number of Machines per Operator—One. Dies and Die Holders—Fig. 151. Pressure Required—About 650 tons total. Production—75 per day. Note—A spool of wire usually consists of five extruded ingots, or about 500 lb.

OPERATION 3. FORMING BALLS ON SPECIAL MACHINE

Transformation—Fig. 153. Machine Used—Special Waterbury-Farrel machine, Figs. 146 and 154. Number of Machines per Operator—Four. Tools—Shearing ring punch, Fig. 155; forming punch and die, Fig. 156; shearing punch and die, Fig. 157; transfer plate, Fig. 158. Cut Data—68 strokes per minute. Production—30,000 per day. Note—500 lb. of wire makes about 380 lb. of balls; the balls for 3-in. shells run 41 to the pound; for 4.7-in. shells, 32 to the pound; and for 6-in., 22.90 to the pound.

OPERATION 3-A. FORMING BALLS ON A PUNCH PRESS AND RUMBLING

Transformation—Fig. 159. Machine Used—Waterbury-Farrel crank press, Figs. 147 and 148. Number of Operators per Machine—Two. Punches and Dies—Fig. 160. Production—200,000 per day. Note—500 to 600 lb. of balls are rumbled at a turn to remove fins left by dies; this operation takes about 15 min.; press runs 80 strokes per minute and takes 12 wires at once.

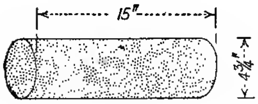


FIG. 143

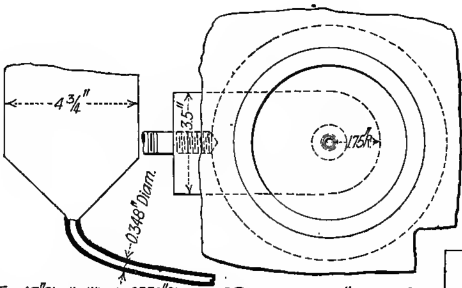


FIG. 150

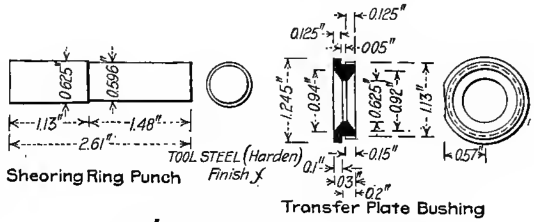
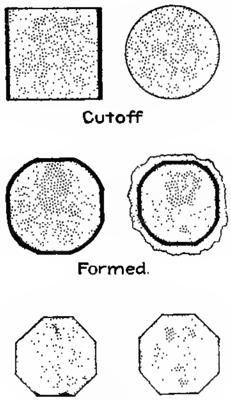


FIG. 155



Cutoff

Formed.

Sheared

FIG. 153

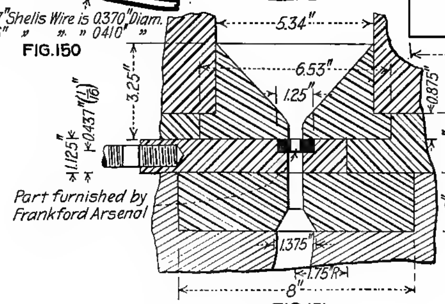


FIG. 151

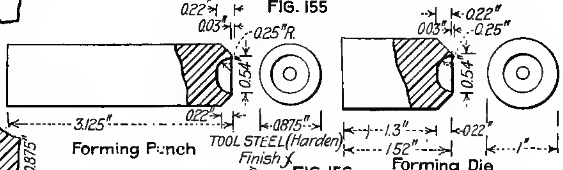


FIG. 156

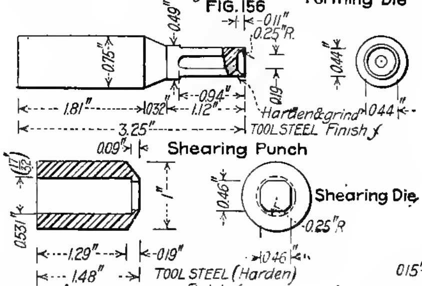


FIG. 157

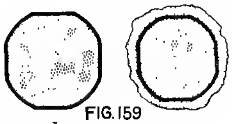


FIG. 159

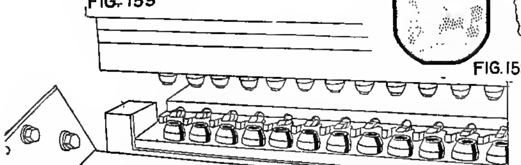


FIG. 160

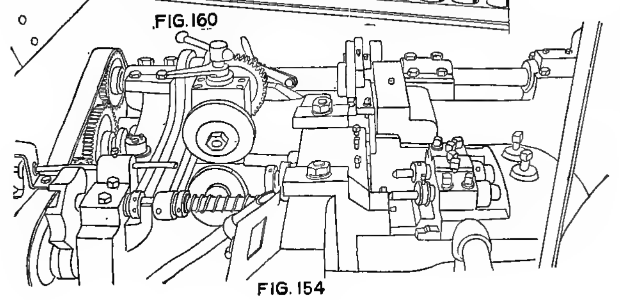


FIG. 154

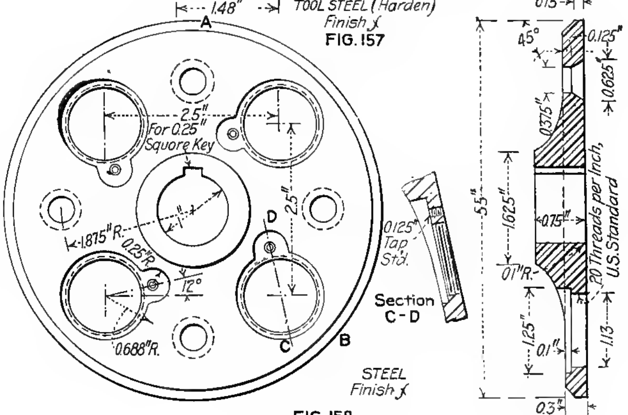


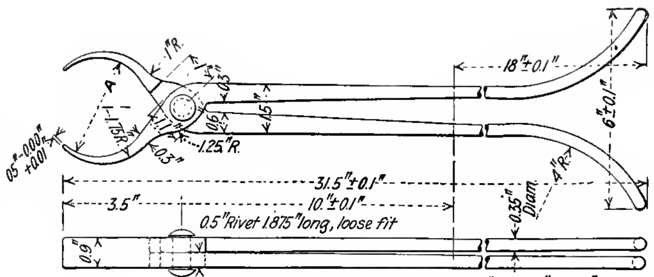
FIG. 158

Commonly, however, the hexagon balls are made on the special machines and the spherical ones on the press.

The mix for the balls is melted in large pots and cast into ingots. A furnace and a mold are shown in Fig. 144. The mold in the foreground is water cooled and so made as to be swung over on trunnions, allowing the cooled ingot to drop out.

As shown in Fig. 145, the wire from which the balls are made is extruded in a hydraulic press. As the wire issues from the die, it is carried down through a trough of water. At the farther end of the trough it runs over a large grooved pulley carried in a "floating" frame. From this pulley the wire is run back toward the press and is automatically wound on a reel. Friction drive is used in the reel-turning mechanism, adjusted so that the wire will be closely wound, but not pulled so hard as to sever it.

In making balls on the type of machine shown in Fig. 146 a reel of wire is placed in the bracket and fed into the machine. A cam-operated slide cuts the wire off into short slugs, which are carried over and fed into a rotating disk. This disk carries the slug between two forming punches, which compress and form the lead into a ball. As the disk again indexes, the ball is carried to the next set of dies, where the flash is trimmed off. An extra punch in a slide removes all lead particles that might cling to the dies and cause trouble as the disk indexes to the different positions.



FORGED STEEL
FIG. 161, OP. 1

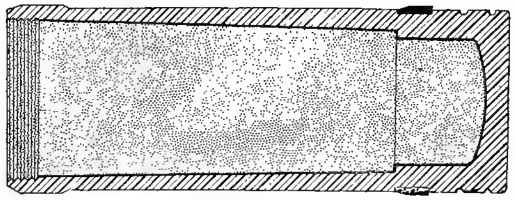


FIG. 162

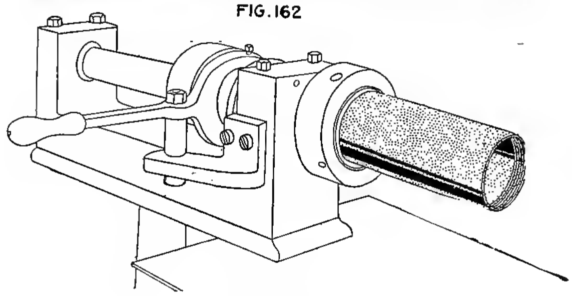


FIG. 163
OPERATION 2

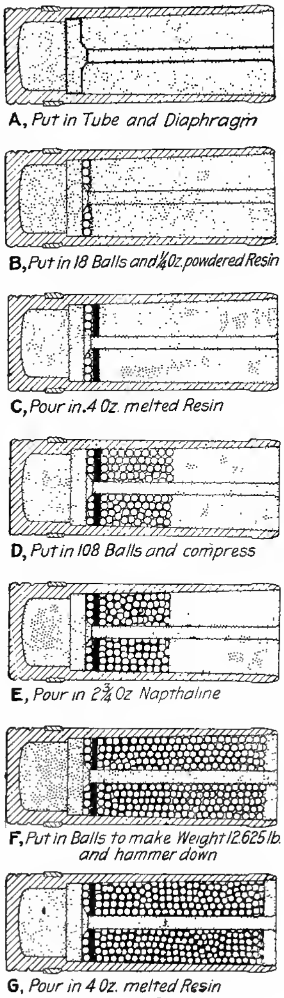
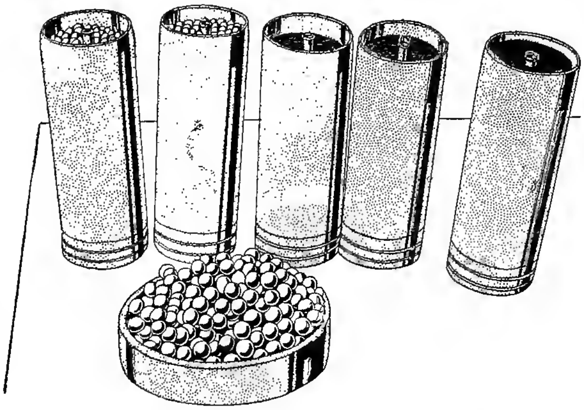


FIG. 164



164 A

OPERATION 3

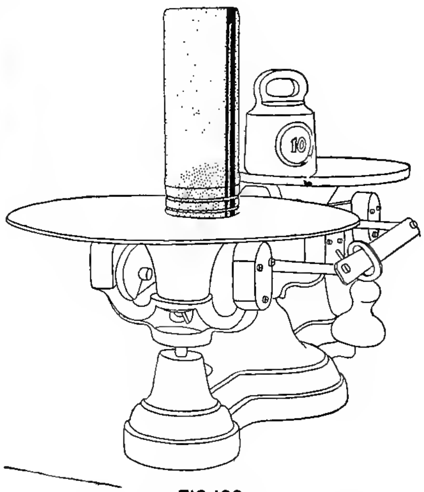


FIG. 166

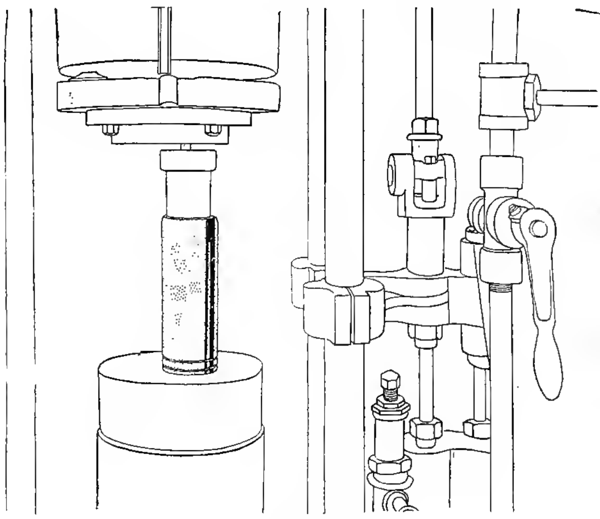


FIG. 165

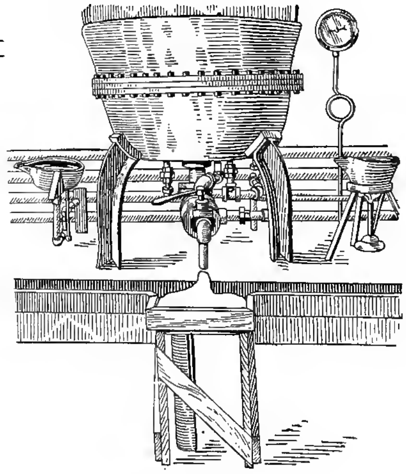


FIG. 167

Where the balls are made on a punch press, as shown in Figs. 147 and 148, twelve are made at each stroke of the press. The 12 reels are carried on a slanting frame in such a way that any individual reel may be removed and replaced without disturbing the others. This is especially necessary, as it is impossible to empty the reels all at once on account of varying lengths of wire.

After the balls are formed in the press, they drop into a tumbling barrel placed close to the machine, as shown at the back in Fig. 148. The balls are tumbled in this to remove the flash, the rubbing together accomplishing the desired result.

After the case has been washed in hot soda water, the interior is painted and then is ready for assembling and for receiving the balls. The standard shop directions for this operation are as follows:

Make sure that the diaphragm seats very firmly on the shoulder; pour in 0.25 oz. powdered resin to seal joints and shake down well to fill all cracks. The powdered resin becomes plastic when the melted resin is poured in.

Put in one layer of balls (18) and pour in 0.4 oz. of melted resin. Put in 108 balls and settle by a pressure of 6 tons. Pour in 2.25 oz. of melted pure white commercial naphthalene. Put in sufficient number of balls to bring the weight to 12.625 lb. Drive down with mallet and pour in 4 oz. of melted resin. After the mass has thoroughly cooled, face off matrix so that the depth from end of case shall be 0.35 in. to allow for screwing in of head, which should bear down hard on matrix.

Final Operations

Assembling

OPERATION 1. WASH CASE IN HOT SODA WATER

Number of Operators—One. Description of Operation—Operator places case in solution until grease is cut off, then rinses in hot water and drains it. Apparatus and Equipment Used—Tongs, Fig. 161; tank of Wyandotte metal-cleaner solution; tank of hot water. Production—350 per day.

OPERATION 2. PAINT INTERIOR

Transformation—Fig. 162. Number of Operators—One. Description of Operation—Operator chucks case and applies the paint inside so as not to daub up the threads; machine runs 140 r.p.m. Apparatus and Equipment Used—Small special machine, Fig. 163; pot of asphaltum varnish; long-handled brush. Production—1000 per day.

OPERATIONS 3-A, 3-B AND 3-C. ASSEMBLE TUBE AND DIAPHRAGM, FILL CASE, COMPRESS BALLS

Transformation—Figs. 164 and 164-A. Number of Operators—Two. Description of Operation—First operator puts in diaphragm and tube, making sure the diaphragm seats firmly; then he pours in ¼ oz. powdered resin; next, he places a layer of 18 balls on the diaphragm and pours in 0.4 oz. of melted resin; 108 balls are put in and pressed down by second operator with 6 tons' pressure; 2¼ oz. of melted pure white commercial naphthalene is poured in; sufficient balls are next added to bring weight to 12.625 lb.; these balls are driven down with mallet, and 4 oz. of melted resin is poured in. Apparatus and Equipment Used—Watson-Stillman hydraulic press, Fig. 165; scale, Fig. 166; melting pots for resin and naphthalene, Fig. 167; mallet. Production—340 per 8-hr. day.

OPERATION 4. CUT OUT SURPLUS RESIN

Transformation—Fig. 168. Machine Used—Small lathe, Fig. 169. Number of Operators per Machine—One. Work-Holding Devices—Special chuck, Fig. 170. Tool-Holding Devices—Shank for cutter, Fig. 171. Cutting Tools—Resin cutter, Fig. 172. Cut Data—250 r.p.m. Gages—Depth, Fig. 173. Production—1000 per 8 hr.

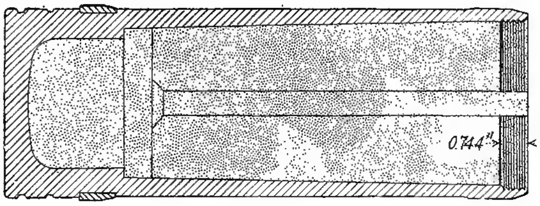


FIG. 168

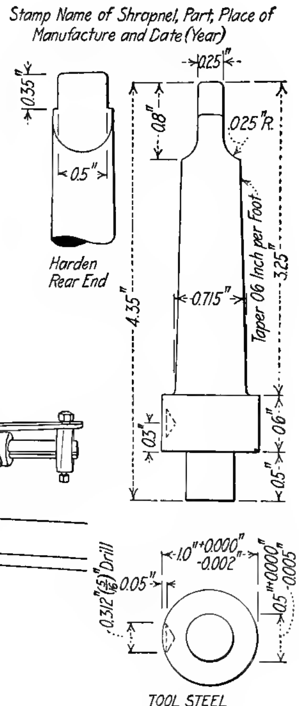


FIG. 171

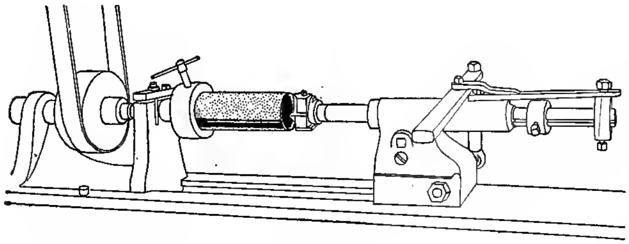


FIG. 169

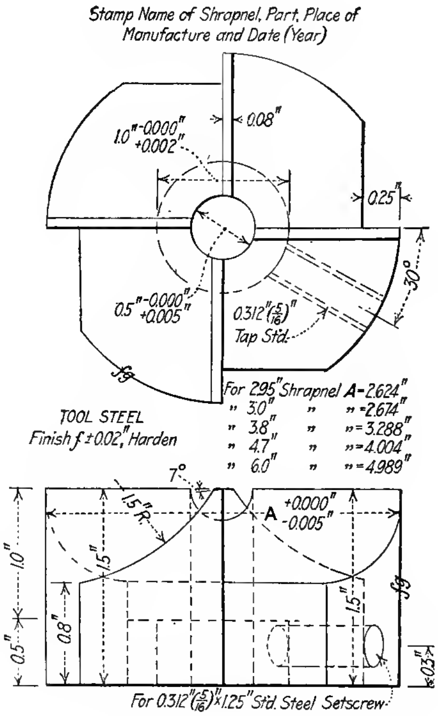


FIG. 172

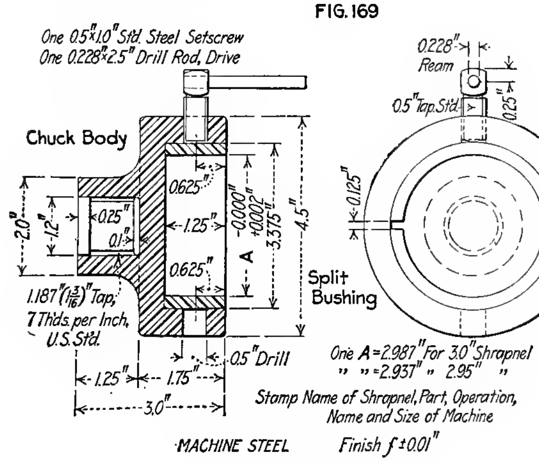


FIG. 170

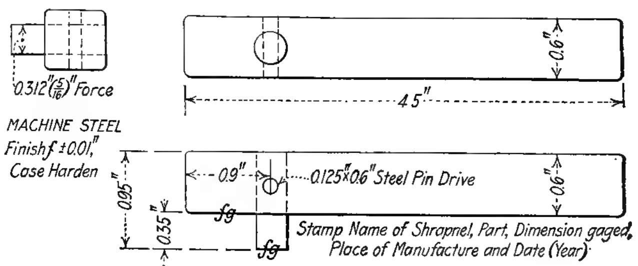


FIG. 173

OPERATION 4

OPERATION 5. MOISTEN THREADS OF HEAD WITH COSMOLINE, ASSEMBLE HEAD TO CASE AND INSERT INNER TUBE

Transformation—Fig. 174. Number of Operators—One. Description of Operation—Operator brushes a little cosmoline on threads of head, places case in bench holding block and screws head into place, Fig. 175; he then puts in inner tube and hammers it in place with hammer and special punch, Fig. 176. Apparatus and Equipment Used—Holding block; wrench, Fig. 177; punch, Fig. 178; hammer. Production—515 per day.

OPERATION 6. PIN HEAD TO CASE

Transformation—Fig. 179. Machine Used—Small drilling machine, Fig. 180. Number of Operators per Machine—One. Tool-Holding Devices—Drill chuck. Cutting Tools—No. 31 twist drill. Special Fixtures—Fixture to hold case, Fig. 187. Production—600 per 8 hr. Note—Pins are supplied of correct size and are driven in by hand.

OPERATION 7. TURN BOURRELET (WHEN CASES ARE FINISHED BY OUTSIDE CONTRACT)

Transformation—Fig. 182. Machine Used—Le Blond 17-in. lathe. Number of Operators per Machine—One. Work-Holding Devices—Special chuck, Fig. 184; steadyrest. Cutting Tools—Left-hand lathe tool. Cut Data—50 ft. surface speed. Special Fixtures—Split bushing; form and form follower, Fig. 183. Gages—Maximum diameter, ring, Fig. 43; minimum diameter, ring, Fig. 44; diameter, nose thread, plug, Fig. 45. Production—180 per 8 hr.

In all cases where two parts are screwed together it is the practice to put on enough cosmoline to coat the threads. This is simply slushed on with a small brush. With the threads moistened with cosmoline, the head is screwed into the case, using the special wrench and holding block shown in Fig. 175.

Following this the same operator forces in the inner tube with a punch and hammer, as shown in Fig. 176, the two transformations *A* and *B*, Fig. 174, showing what is done. Details of both the wrench and punch are given in Figs. 177 and 178.

The pinning of the head to the case is done by one operator who first drills the two holes in a small drilling machine, using a special holding fixture as shown in Fig. 180, the details being given in Fig. 181. After drilling the holes he drives in small pins, which are bought in quantities for the purpose.

No accurate spacing of the pin-holes is necessary, the operator drilling them approximately opposite each other.

The turning of the bourrelet indicated in operation 7, is only done where the cases are finished by outside contractors, as when they are machined at the arsenal the bourrelet is finished along with the point.

The grooving for the waterproof cover is done in a lathe, the shell being held in a special screw chuck, Fig. 187, in conjunction with a revolving tail center, Fig. 189, the cutting tool used being shown in Fig. 188.

Painting of the outside is done by chucking the shell in a lathe and applying the paint in broad bands with a brush, the operator after a little practice judging the width of the bands with his eye. On large shells they are held in a vertical position on a rotating fixture, the operator using pointers on an upright piece to indicate the width of the bands until accustomed to his work.

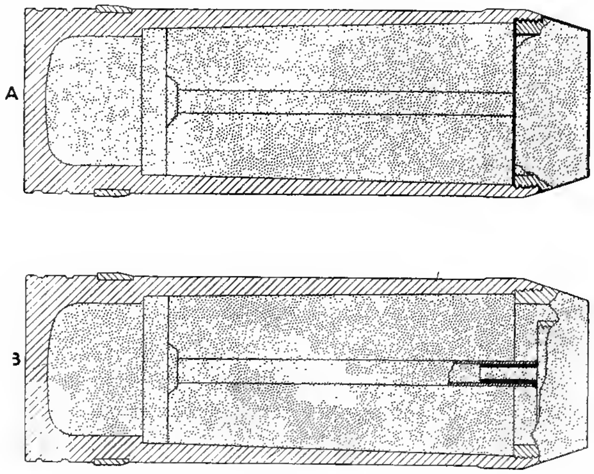


FIG. 174

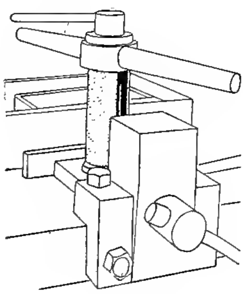


FIG. 175

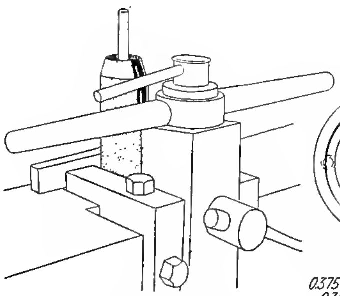


FIG. 176

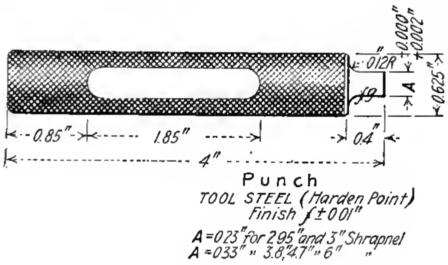


FIG. 178

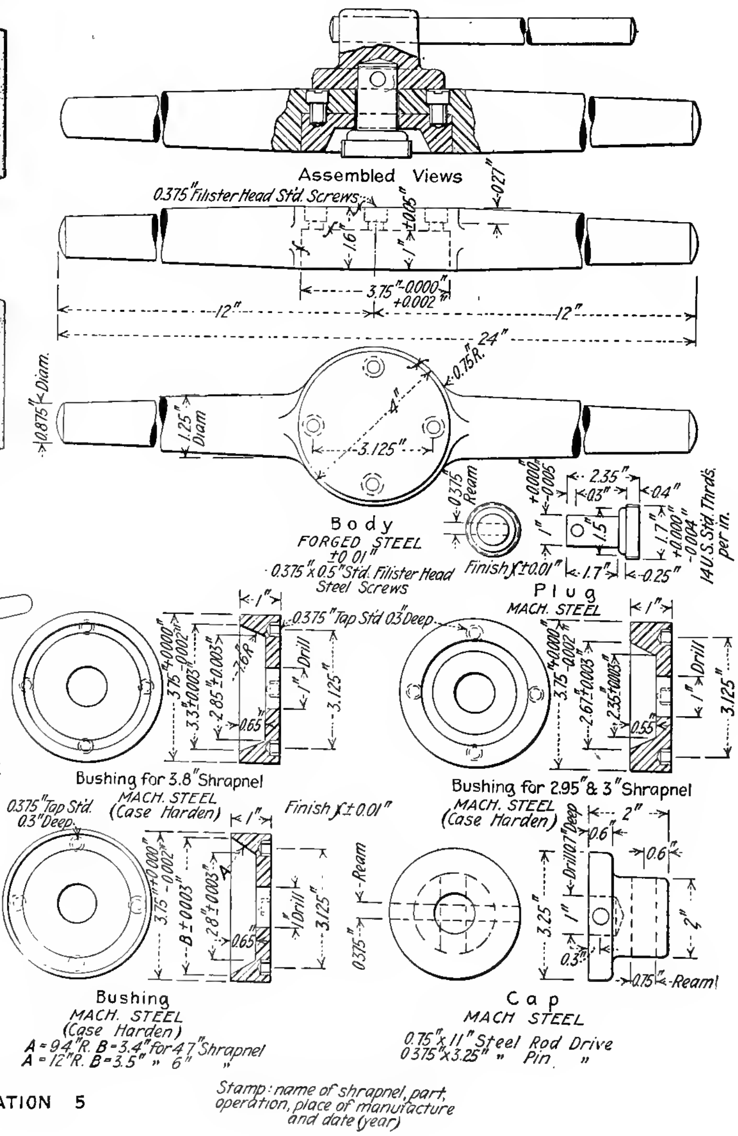
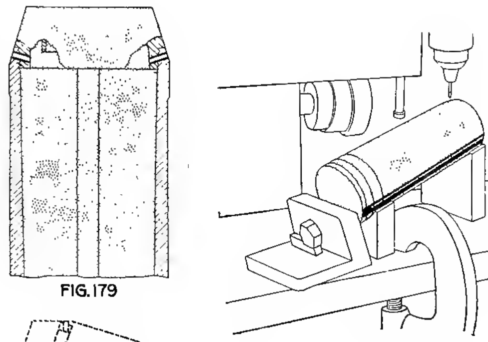
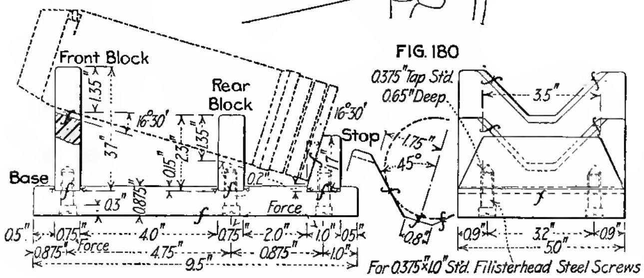


FIG. 177

The paints used are for two purposes: (a) To protect metal from corrosion, and (b) to identify different kinds of projectiles and contents. Red indicates a bursting charge, or high explosive; gray, forged-steel case; yellow, explosive of low power; olive green, cast iron; and so on. In some cases slushing oil is put on back of the band; but where it is not to be immediately assembled with the cartridge case, red paint is used.

The various colors and the method of mixing are here given, the exact proportions being given in each case.





MACHINE STEEL
FIG. 181
OPERATION 6

Body (Black)—1 Gal.:

Lampblack, dry	1 lb.
Linseed oil, raw	7/16 gal
Texene	5/16 gal
Japan drier	1/16 gal
Copal varnish	1/16 gal

Cast Iron (Light Olive Green)—1 Gal.:

French yellow ocher, in oil	7¾ lb.
Lemon chrome yellow, in oil	15 oz.
Chrome green, in oil	6 oz.
Lampblack, in oil	3 oz.
Linseed oil, raw	5/16 gal.
Texene	⅛ gal
Japan drier	1/32 gal.
Copal varnish	1/32 gal.

Powder (Vermilion)—1 Gal.:

Deepfast vermilion, in oil	2 lb.
Red lead, dry	7 lb.
Whiting, dry	4½ lb.
Linseed oil, raw	⅝ gal.
Japan drier	1/16 gal.

Priming Coat (Red)—1 Gal.:

Red lead, dry	10 lb.
Whiting, dry	4 lb.
Linseed oil, raw	¾ gal.
Japan drier	1/16 gal.

Explosive D (Deep Yellow)—1 Gal.:

French yellow ocher, in oil	7½ lb.
English Venetian red, in oil	3 oz.
Lemon chrome yellow	4½ lb.
Linseed oil, raw	⅛ gal.
Texene	3/16 gal.
Japan drier	1/32 gal.
Copal varnish	1/32 gal.

Cast Steel (Warm Gray)—1 Gal.:

White lead, in oil	8 lb.
Whiting, dry	4½ lb.
French yellow ocher, in oil	¾ lb.
Lampblack, in oil	½ oz.
Lemon chrome yellow, in oil	1 oz.
Linseed oil, raw	5/16 gal.
Texene	3/16 gal.
Japan drier	1/16 gal.
Copal varnish	1/16 gal.

Forged Steel (Blue Gray)—1 Gal.:

White lead, in oil	7 lb.
Whiting, dry	5 lb.
Lampblack, in oil	3 oz.
Linseed oil, raw	⅜ gal.
Texene	3/16 gal.
Japan drier	1/16 gal.
Copal varnish	1/16 gal.

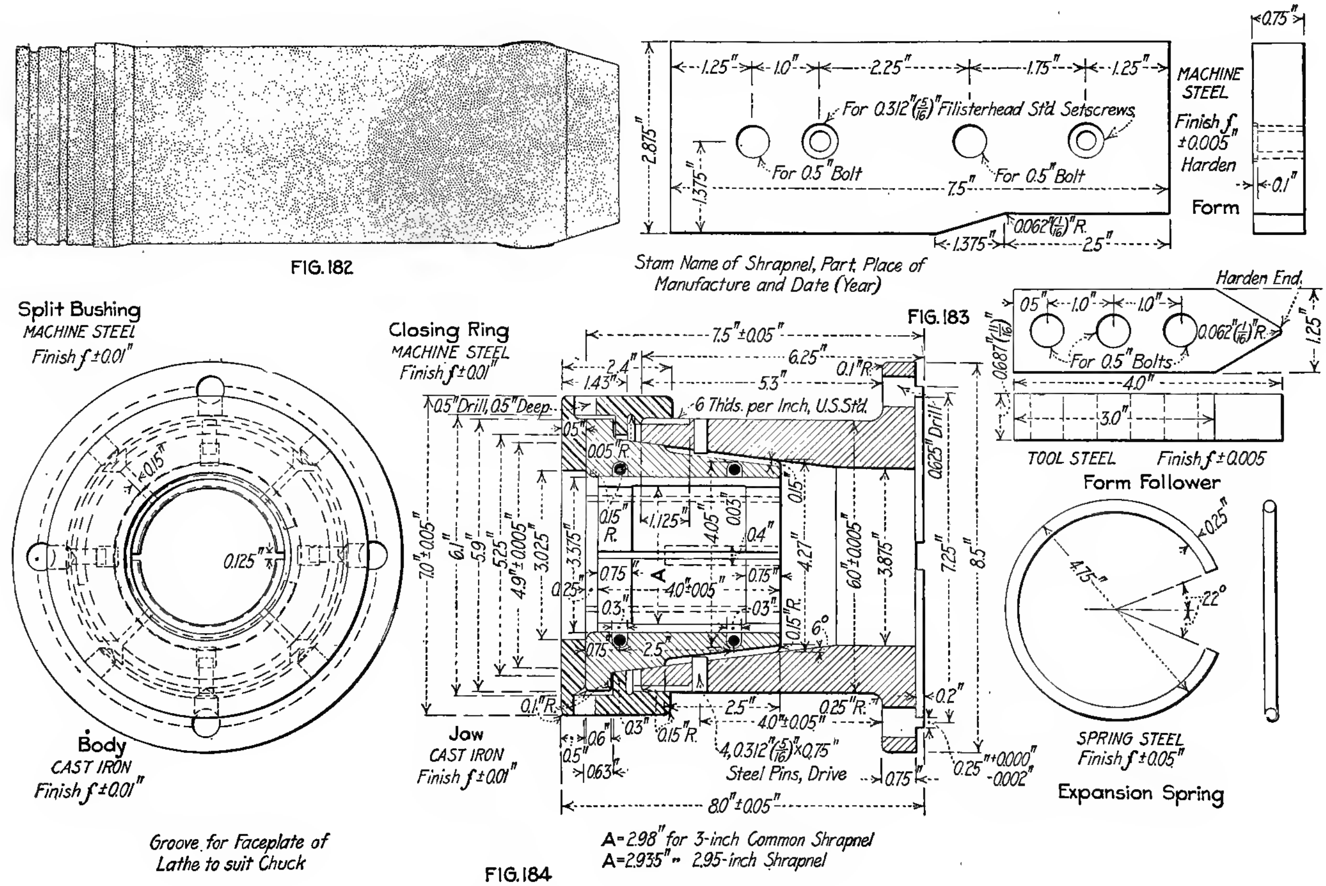


FIG. 184
OPERATION 7

The powder charge is loaded in the machine shown in Fig. 149. The shells are placed in rotating holders, and a funnel is swung over them. The powder charge is then poured into the funnel and runs down through the center tube into the powder chamber. A second operator then takes the shell and pokes a small wad of gun cotton down into the center tube to hold the powder in place.

Following the loading, the shells go to a gang of three men, who put on the fuse. The first brushes cosmoline on the threads and partly screws in the fuse. The next man sets the shell in a bench chuck, Fig. 195, screws down the fuse and locks it in place with punch and hammer. The third man places the fuse setter over the fuse and sets it to the safety point.

From this gang the shell goes to the crimping machine, Fig. 197. The operator paints the cover groove, slips a brass waterproof cover in the holder, places the shell in the fixture and starts the machine. The disk roller revolves around the head and securely crimps the cover in place. Following this the edges of the cover and the junction with the shell are painted by hand with asphaltum varnish in order that the joint may be water-tight.

OPERATION 8. GROOVE FOR WATERPROOF COVER

Transformation—Fig. 185. Machine Used—Le Blond 17-in. lathe, Fig. 186. Number of Operators per Machine—One. Work-Holding Devices—Special screw chuck, Fig. 187. Cutting Tools—Special lathe tool, Fig. 188. Cut Data—50 ft. surface speed. Special Fixtures—Revolving center, Fig. 189. Gages—Position, scratch gage, Fig. 190; position gage, Fig. 191. Production—600 per 8 hr.

OPERATION 9. PAINT OUTSIDE

Transformation — Fig. 192. Number of Operators — One. Description of Operation—Operator chucks butt end of case in small lathe and applies paint with wide brushes. Apparatus and Equipment Used—Pot of black paint, pot of yellow paint, two brushes. Production—800 per day. Note—Machine runs 250 r.p.m.

OPERATION 10. LOAD POWDER CHARGE

Transformation—Fig. 193. Number of Operators—Three (two loaders and a trucker). Description of Operation—Cases are placed in the revolving fixtures shown, and 1180 gr. shrapnel powder is poured in through the funnels; next, a wad of gun cotton is pushed down through the tube to retain the powder and assist ignition; powder is measured by means of the little dipper shown on the bench; the cases rotate about 200 r.p.m. as the powder runs in through a $\frac{3}{32}$-in. opening in the funnels. Apparatus and Equipment Used—Loading fixtures, Fig. 149; measuring dipper; trucks. Production—2200 per day per gang.

OPERATION 11. BRUSH COSMOLINE ON FUSE THREADS

Number of Operators—One (three in gang). Production—1200 per day. Note—Three men do operations 11, 12 and 13 in succession.

OPERATION 12. SCREW IN FUSE AND LOCK

Transformation—Fig. 194. Number of Operators—One (in gang of three). Apparatus and Equipment Used—Bench chuck, wrench, punch and hammer, as shown in Fig. 195. Production—1200 per day.

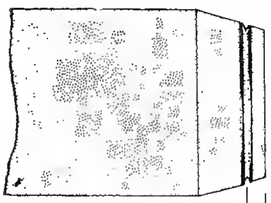


FIG. 185

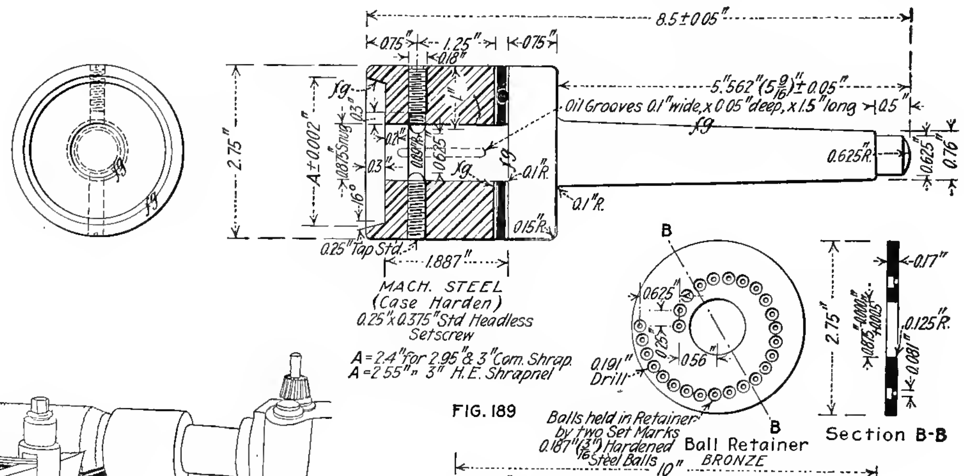


FIG. 189

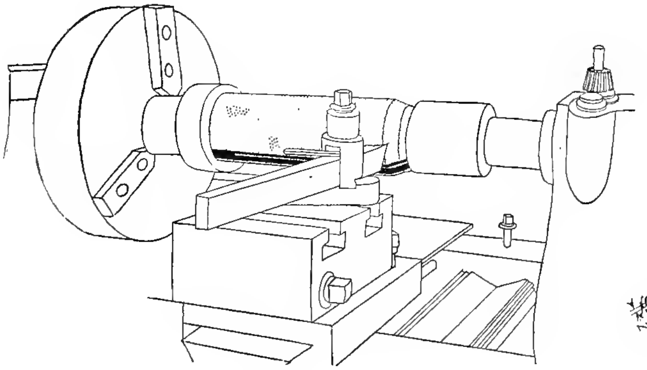


FIG. 186

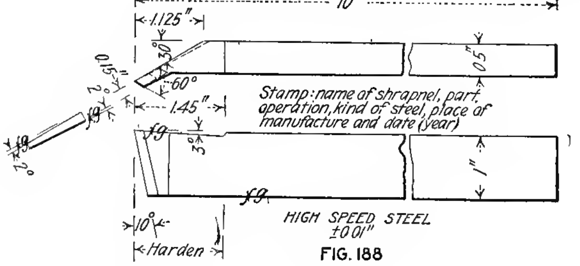


FIG. 188

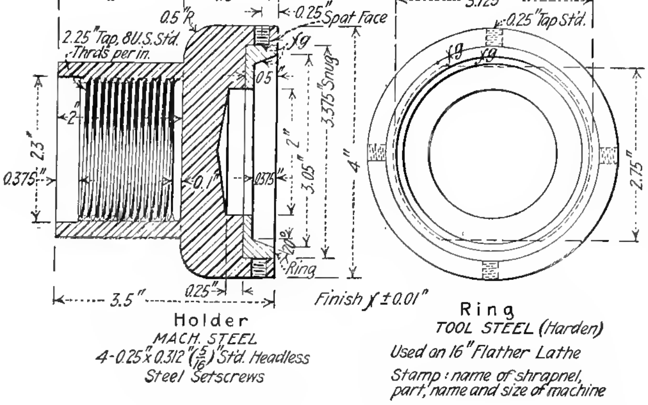


FIG. 187

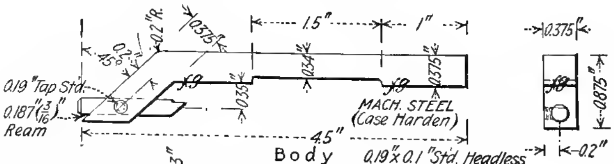


FIG. 190

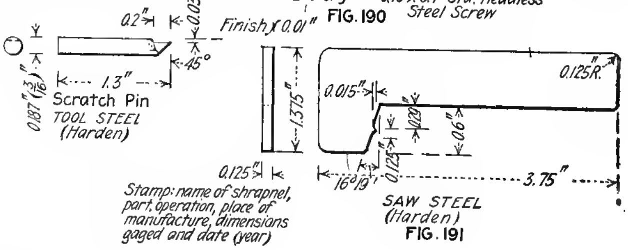


FIG. 191

OPERATION 8

OPERATION 13. SET FUSE TO SAFETY POINT

Number of Operators—One (in gang of three). Description of Operation—Operator places projectile in chuck, places fuse setter over the fuse nose, as shown in Fig. 196, and sets fuse to safety point. Production—1200 per day.

OPERATION 14. CRIMP ON WATERPROOF COVER

Transformation—Fig. 196. Machine Used—Lathe, Fig. 197. Method of Operation—Operator spreads asphaltum paint in the groove with a brush, presses on waterproof cover and places in machine, as shown; he then sets lever so that roller will press metal of cover into groove and starts machine; afterward he coats junction of cover and head with asphaltum paint to make water-tight; another slightly different form of machine is shown in Fig. 198; these machines run about 50 r.p.m. Production—700 per day.

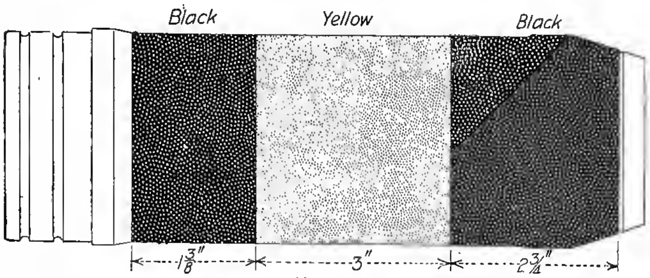


FIG. 192
OPERATION 9

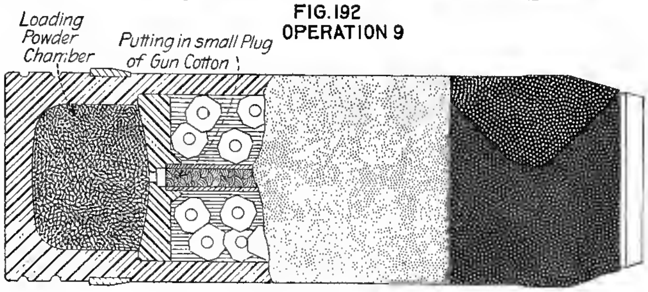


FIG. 193
OPERATION 10

Operations That Have Been Omitted

In the foregoing article a number of operations of considerable importance have not been described in detail for the reason that they are the same as those on the 3-in. common steel shell, which will be described in a subsequent article. For instance the making of the copper band will later be given in detail from the time it is cut from copper tubing through all the steps, such as pickling, planishing, heating, pressing into place and finishing.

The night tracer will also be described and will be found of considerable interest. These tracers are made from brass rod, in automatic machines, so that the machining is not as interesting as the process of loading, which must be so arranged that the trail of fire does not show until the shell is some distance from the muzzle of the gun. Otherwise the position of the piece would be revealed to the enemy and afford a well-located target. The explosion of the propelling charge first ignites a slow-burning powder, which in turn sets off an ignition mixture followed by the blazing of the illuminant.

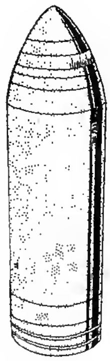


FIG. 194

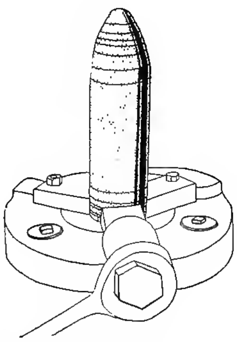


FIG. 195
OPERATION 12

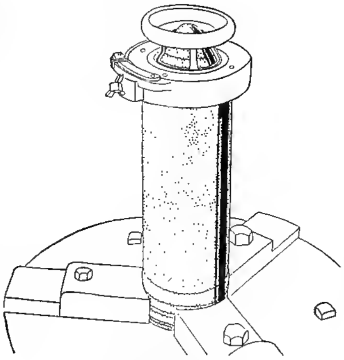


FIG. 196
OPERATION 13

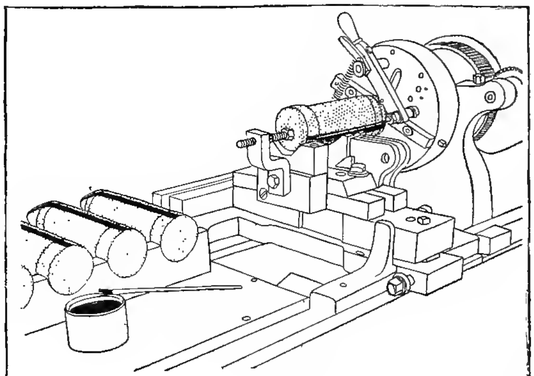


FIG. 198

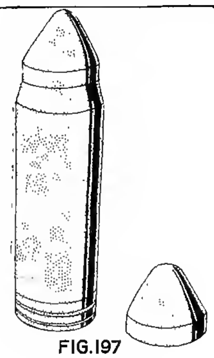
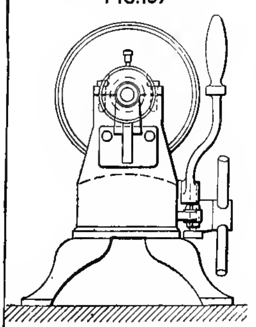
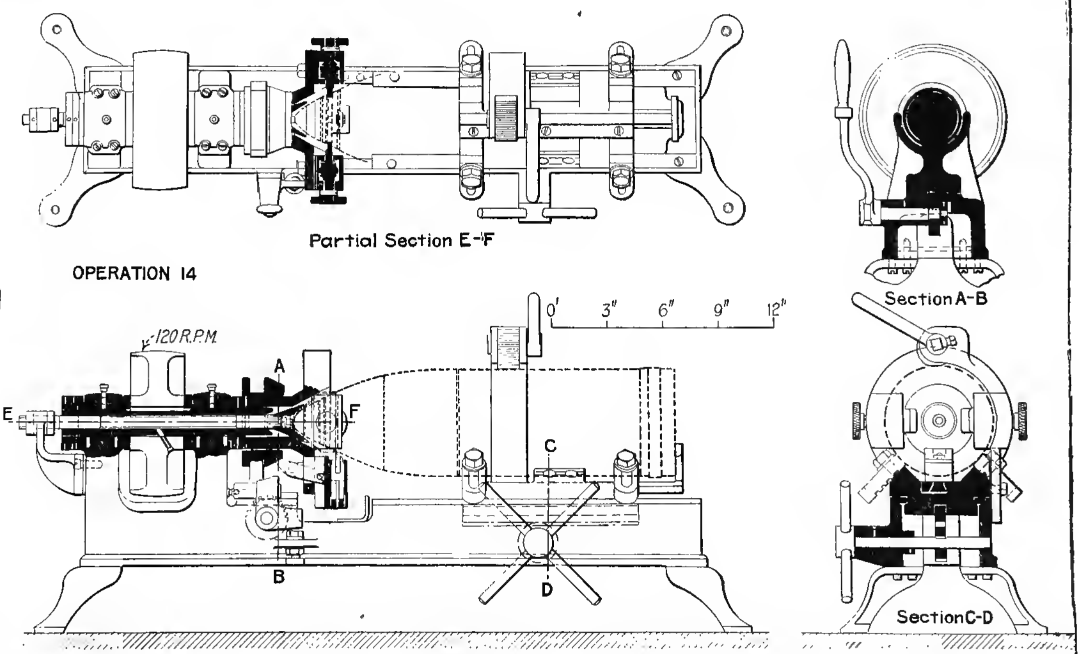


FIG. 197





OPERATION 14

FIG. 199

United States Munitions*

The 3-In. Common Steel Shell

United States 3-In. Common Shell

The high-explosive, or common, steel shell, as it is called, is of the solid-point, base-detonating type, which explodes only on impact and cannot be set for time explosion. The explosive carried by the shell is trinitrotoluol, which is forced into the interior of the shell under heavy hydraulic pressure. The base detonator that causes the shell to explode when it strikes is so made that it only becomes active after the shell is fired from the gun. This makes possible the safe handling of loaded shells, which might be dropped point down for some distance without exploding; the explosion, if one should occur from the shell's being dropped, would not be caused by the action ot the detonator mechanism in any case unless the shell was fired from a gun, as it is the rotation of the shell in flight that sets the mechanism for active operation.

The specifications for the steel used in these shells are practically the same as given for the 3-in. shrapnel; but since it is impracticable to determine the contour of the front end of the cavity after the forging is closed in at the base, this part is inspected by the inspector at the works after the projectiles are punched and before the closing-in operation. Details of the forging as received at the Government arsenals are given in Fig. 1. The finished projectile is shown in Fig. 2. As with the 3-in. shrapnel, 10 per cent. of these shells are fitted with night

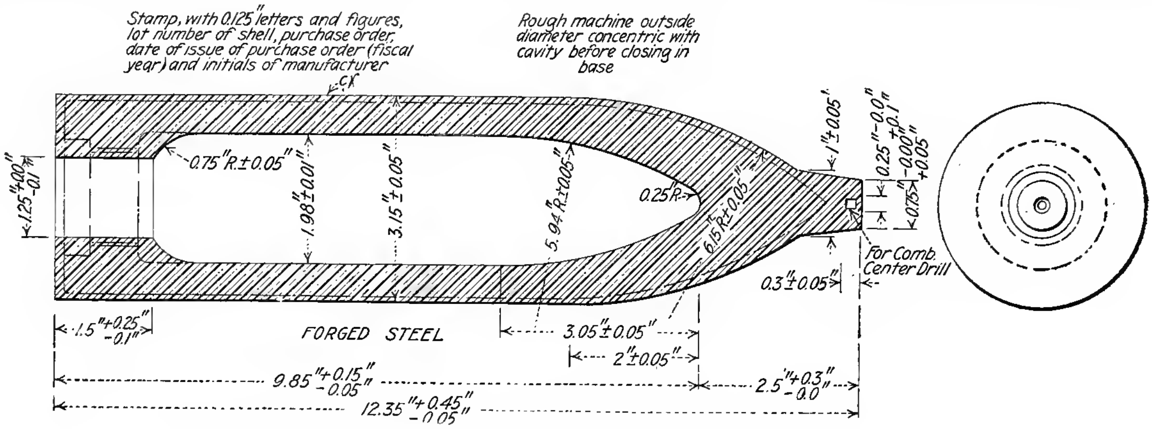


FIG. 1. THREE-INCH COMMON SHELL FORGING

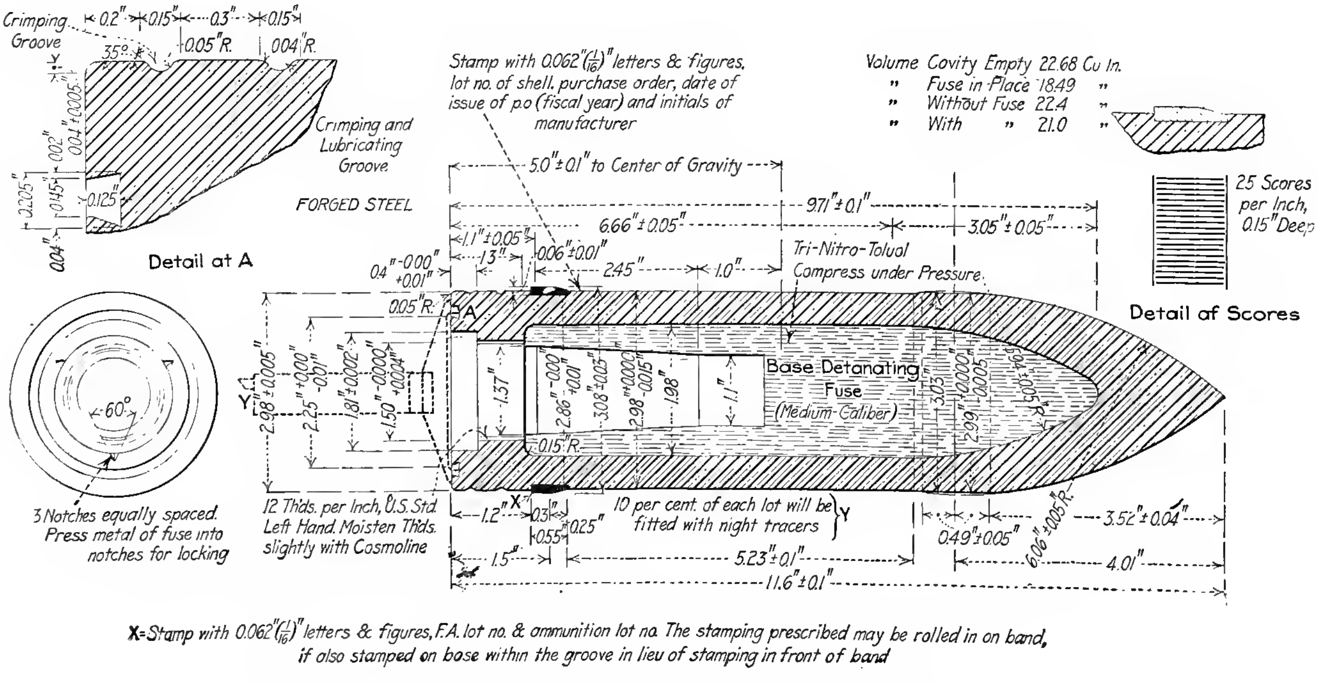


FIG. 2. DETAILS OF COMPLETE PROJECTILE

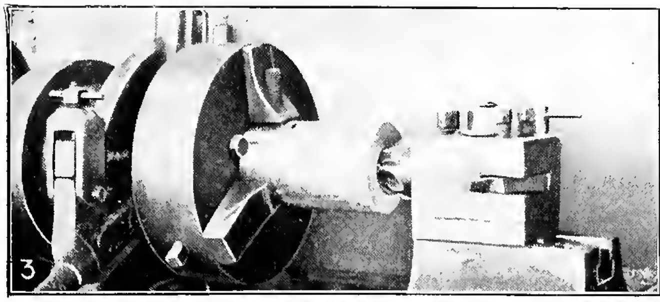


FIG. 3. CENTERING BASE OF FORGING IN A LATHE FITTED WITH CROSS-SLIDE TURRET

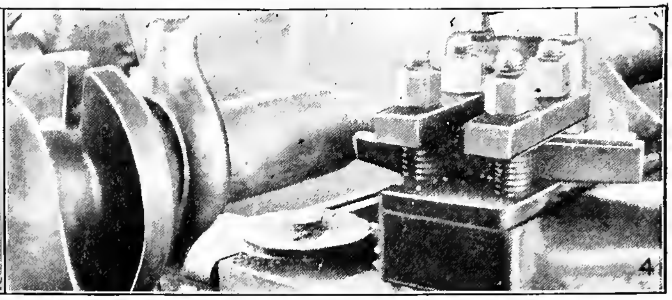


FIG. 4. ROUGH-TURNING THE NOSE OF THE CASE ON A LATHE

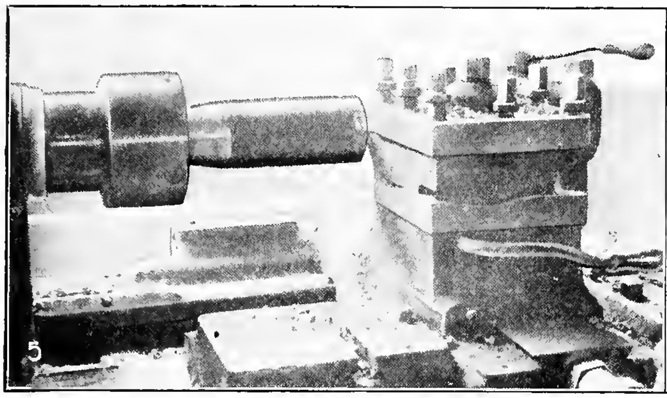


FIG. 5. ROUGH-TURNING BODY, USING A SPECIAL DRIVER AND CENTER

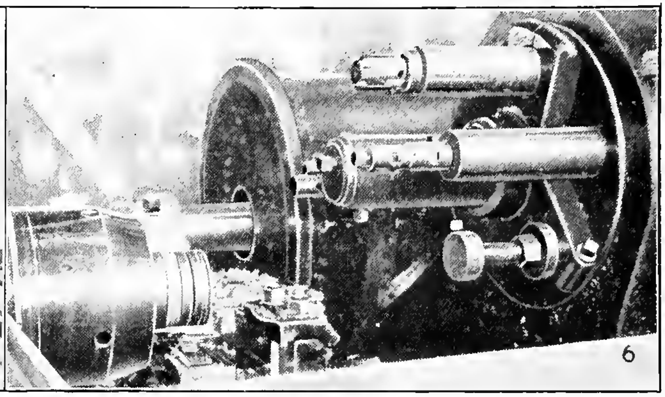


FIG. 6. FINISHING THE BASE ON A CLEVELAND AUTOMATIC SCREW MACHINE

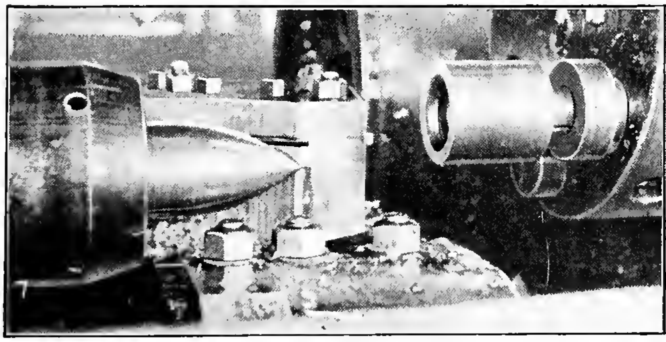


FIG. 7. ROUGH-FORMING AND FINISHING THE POINT AND BOURRELET ON AN AUTOMATIC

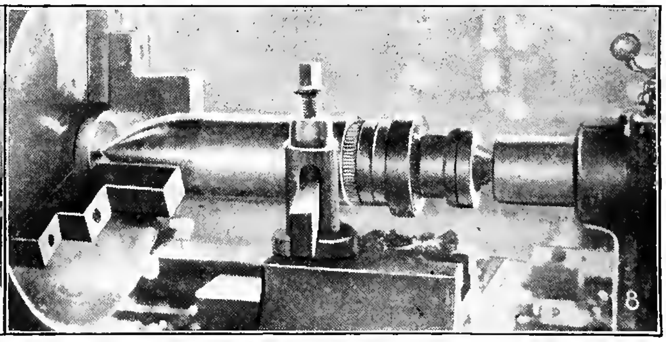


FIG. 8. FINISHING THE BODY, WITH CASE HELD BETWEEN SPECIAL CENTERS

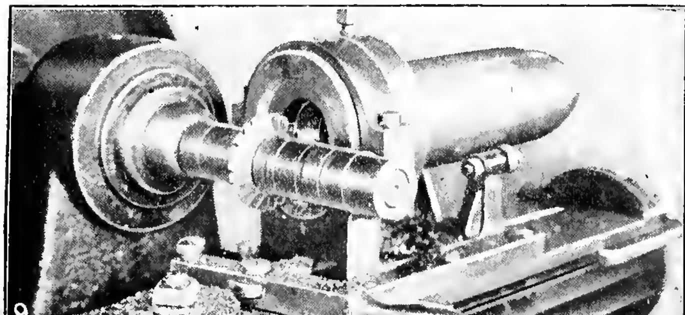


FIG. 9. NOTCHING THE BASE ON A HAND MILLER FITTED WITH SPECIAL FIXTURE

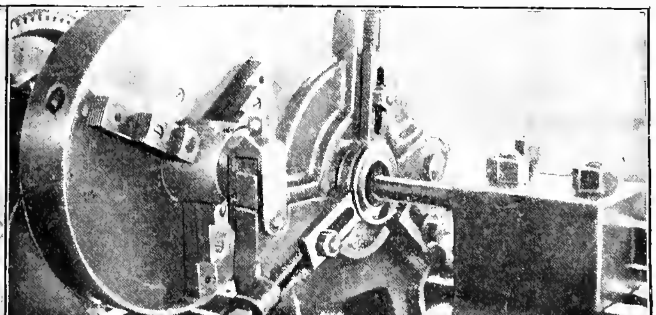


FIG. 10. BORING THE INTERIOR ON A LATHE USING COMMON BORING TOOL

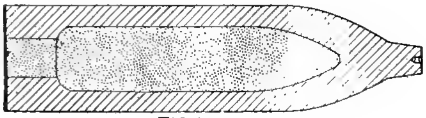
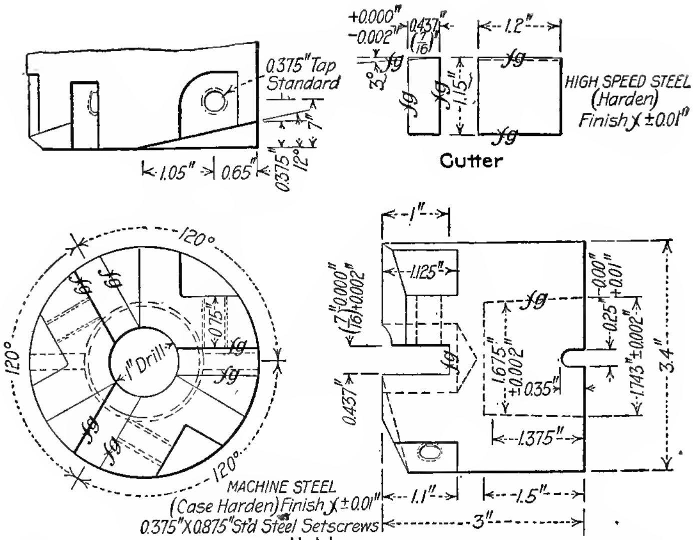


FIG. 11



Holder
FIG. 13

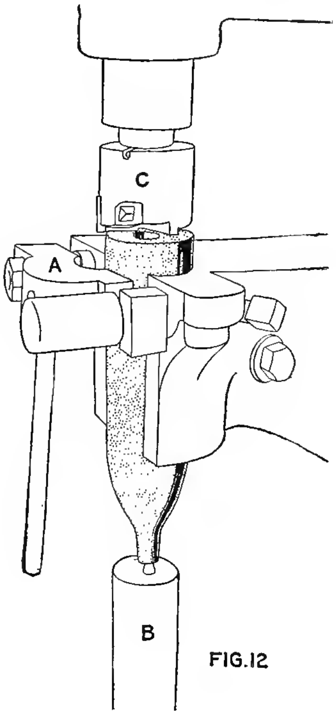
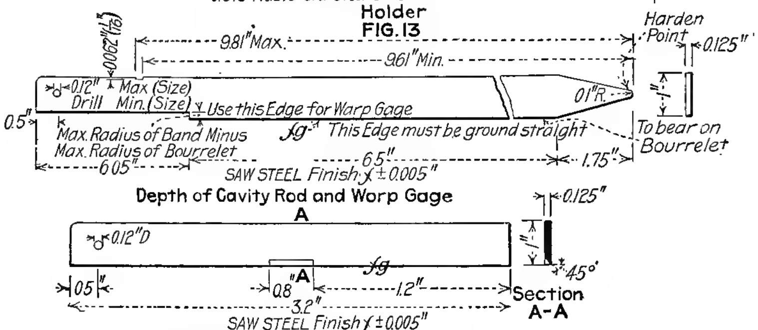


FIG. 12



Cross Bar (Depth of Cavity Rod)

OPERATION I FIG. 14

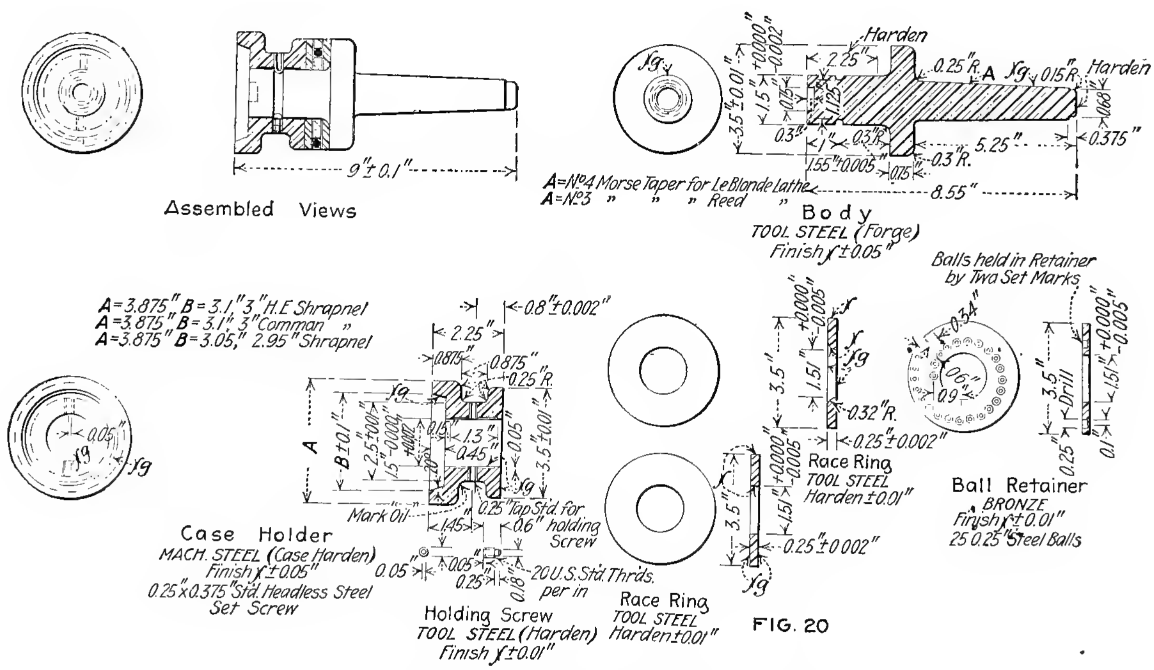


FIG. 20

OPERATION 1. ROUGH-FACE BASE

Transformation—Fig. 11. Machine Used—Prentice upright drilling machine. Number of Operators per Machine—One. Work-Holding Devices—Table knee clamp, Fig. 12-A; bed-plate center, Fig. 12-B. Cutting Tools—Facing cutter with inserted blades, Figs. 12-C and 13. Cut Data—Spindle runs 65 r.p.m. Coolant—None. Average Life of Tool Between Grindings—About ½ day. Gages—Depth of cavity, Fig. 14. Production—400 per 8 hr. Note—Operator must face base close to the maximum limit to allow for finish.

OPERATION 2. CENTER

Transformation—Fig. 15. Machine Used—Reed 18-in. lathe, Fig. 3. Number of Operators per Machine—One. Work-Holding Devices—Steadyrest; three-jaw universal chuck. Tool-Holding Devices—Turret toolholder; Fig. 16. Cutting Tools—Rough-centering tool, Fig. 16-A; centering reamer, Fig. 16-B. Cut Data—170 r.p.m. Coolant—None. Average Life of Tool Between Grindings—About 2 days. Gages—None. Production—400 per 8 hr.

OPERATION 3. ROUGH-TURN POINTS

Transformation—Fig. 17. Machine Used—Le Blond 17-in. lathe, Fig. 4. Number of Operators per Machine—One. Work-Holding Devices—Drive dog and centers; red lead on tail center. Tool-Holding Devices—Toolpost. Cutting Tools—Lathe turning tool. Number of Cuts—Cuts off scale and cleans up entire point. Cut Data—95 r.p.m. Coolant—None. Gages—None. Production—200 per 8 hr.

tracers. The weight of the complete projectile is divided as follows:

	Lb.
Shell (empty), steel	12.355
Band, copper	0.15
Fuse	1.38
Base cover (complete)	0.215
Trinitrotoluol	0.9
Total weight	15 ±0.15

LIST OF OPERATIONS ON THE CASE

1. Rough-face base
2. Center
3. Rough-turn point
4. Rough-turn body
5. Finish-machine base
6. Finish point
7. Finish-turn body
8. Notch base
9. Bore interior
10. Rough base-cover groove
11. Finish base-cover groove
12. Assemble band
13. Turn band on lathe
13-A. Turn band on special machine
14. Resize threads and counterbore; inspect all over
15. Sandblast
16. Hydraulic test

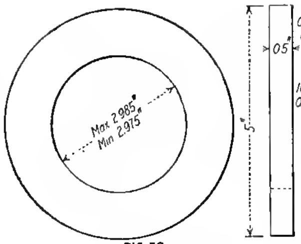


FIG. 39

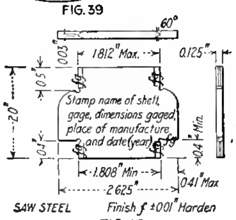


FIG. 40

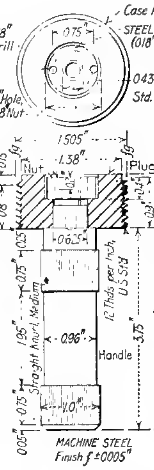


FIG. 41

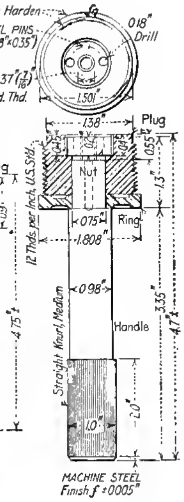
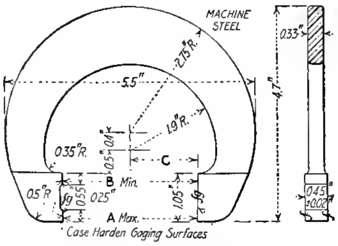


FIG. 42



PART	A	B	C
Band Seat	2.87	2.86	1.43
Body	2.98	2.965	1.5
Bourrelet	2.99	2.985	1.5
Rear of Band	2.985	2.975	1.5

FIG. 43

OPERATION 5

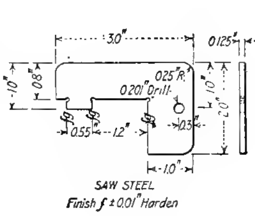


FIG. 44

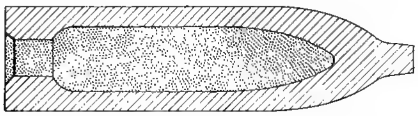


FIG. 15

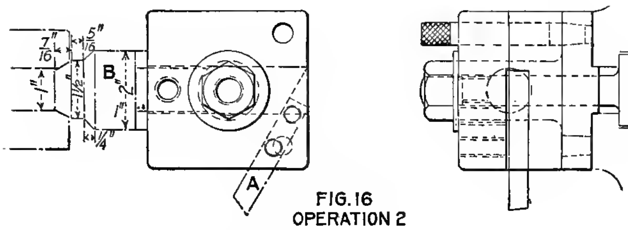


FIG. 16
OPERATION 2

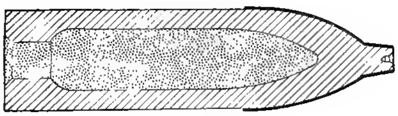


FIG. 17, OP. 3

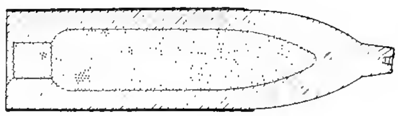
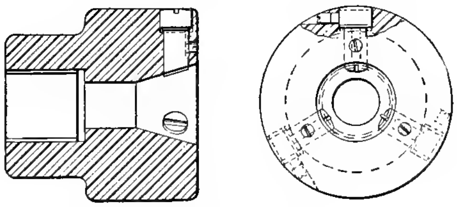
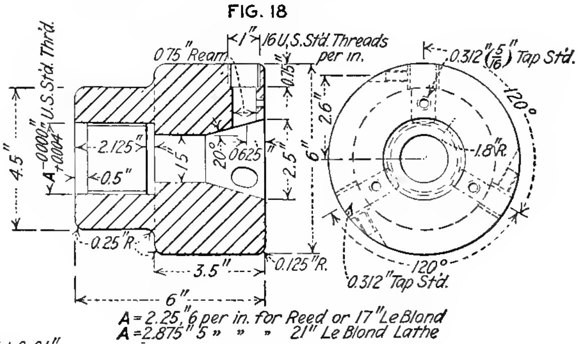


FIG. 18

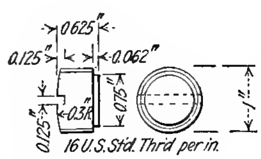


Assembled Views

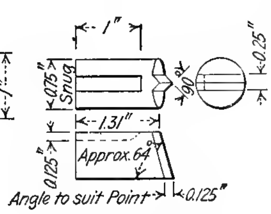


Finish ƒ ± 0.01"
FIG. 19

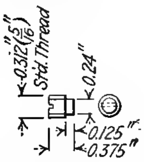
Body
MACH. STEEL
3-0.312 (5/16)" x 0.375" Std. Headless Steel Screws



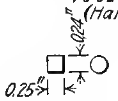
Adjusting Screw
MACH. STEEL
(Case Harden)



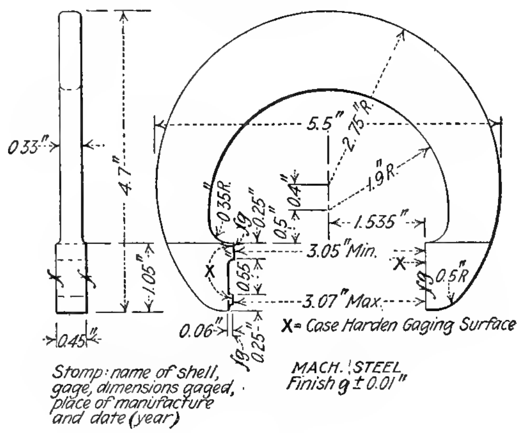
Jaw
TOOL STEEL
(Harden)



Guide Screw
MACH. STEEL
(Case Harden)



Shield
BRASS



OPERATION 4

FIG. 21

The rough-facing of the base is done in a drilling machine fitted with a special cutter and holding fixture, as shown in Fig. 12. The point of the case rests on a centering block, and the body is held in a clamping device. The amount faced off the base is determined by the depth of the cavity, a depth gage being used to indicate this. The tool head is fitted with high-speed steel cutters that are easily reground when dull. When centering the base, the inside edge is first trued up with a single roughing tool; and then the centering reamer and counterbore is run in as shown in Figs. 3 and 16.

Roughing the point consists mainly in turning it to approximate shape, care being taken to get under the scale all around. It will be observed that the case here is held on the tail center, yet no mention has been made of the centering of the point. This will be understood when it is explained that the point is centered by the company that makes the forgings, in order to rough down the outside concentric with the cavity. The body is roughed off in a lathe as shown in Fig. 5, the point being held and driven by a special chuck, Fig. 19; and the base is held on a revolving center, Fig. 20. A standard high-speed turning tool is used for the cut.

OPERATION 4. ROUGH-TURN BODY

Transformation—Fig. 18. Machine Used—Le Blond 17-in. lathe, Fig. 5. Number of Machines per Operator—Two. Work-Holding Devices—Special drive chuck, Fig. 19; revolving plug center. Tool-Holding Devices—Tool post. Cutting Tools—Lathe turning tool. Number of Cuts—One. Cut Data—0.040 in. feed, $\frac{3}{16}$ to ⅛ in. cut, 60 ft. surface speed, 70 r.p.m. Coolant—None. Average Life of Tool Between Grindings—15 pieces. Gages—Combination snap, Fig. 21. Production—200 per 8 hr.

OPERATION 5. FINISH-MACHINE BASE

Transformation—Fig. 22. Machine Used—Cleveland 3¼-in. automatic, Fig. 6. Number of Machines per Operator—Three. Work-Holding Devices—Split collet chuck. Tool-Holding Devices—Holder for combination reamer and counterbore, Fig.

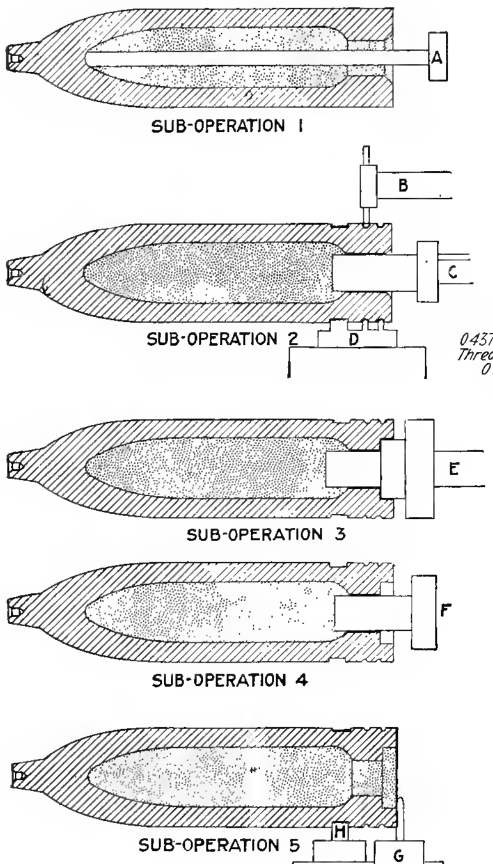


FIG. 22

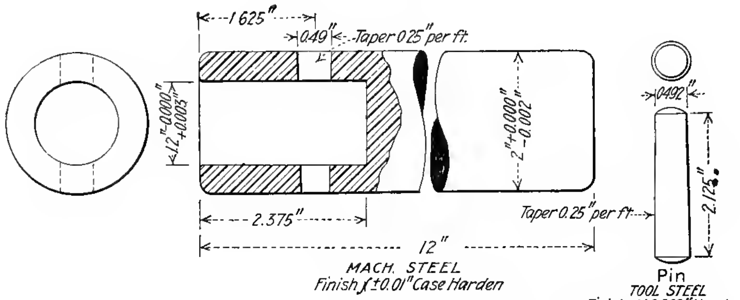


FIG. 23

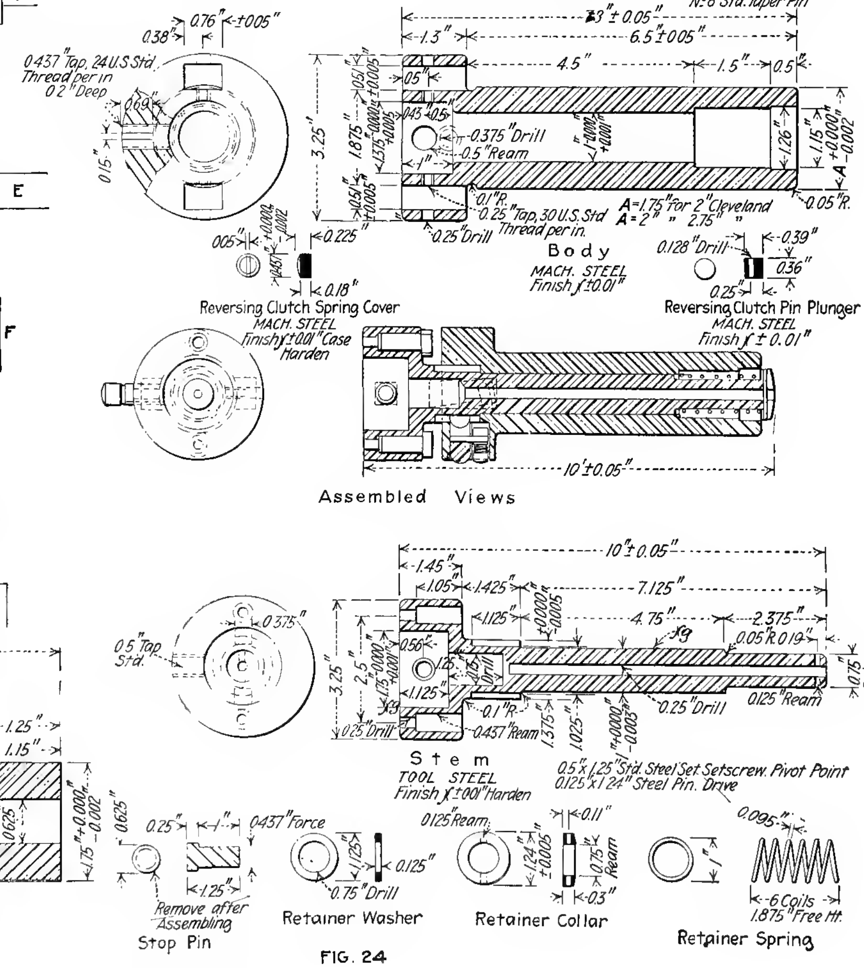


FIG. 24

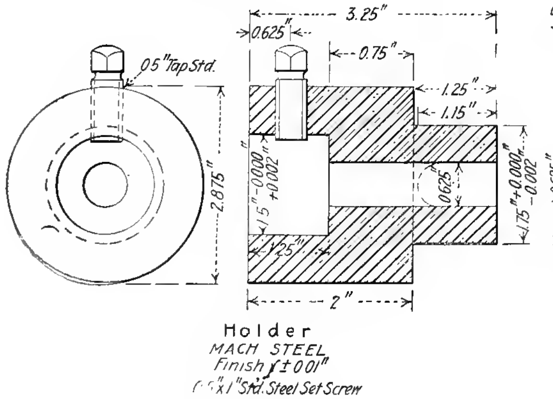


FIG. 25

OPERATION 5

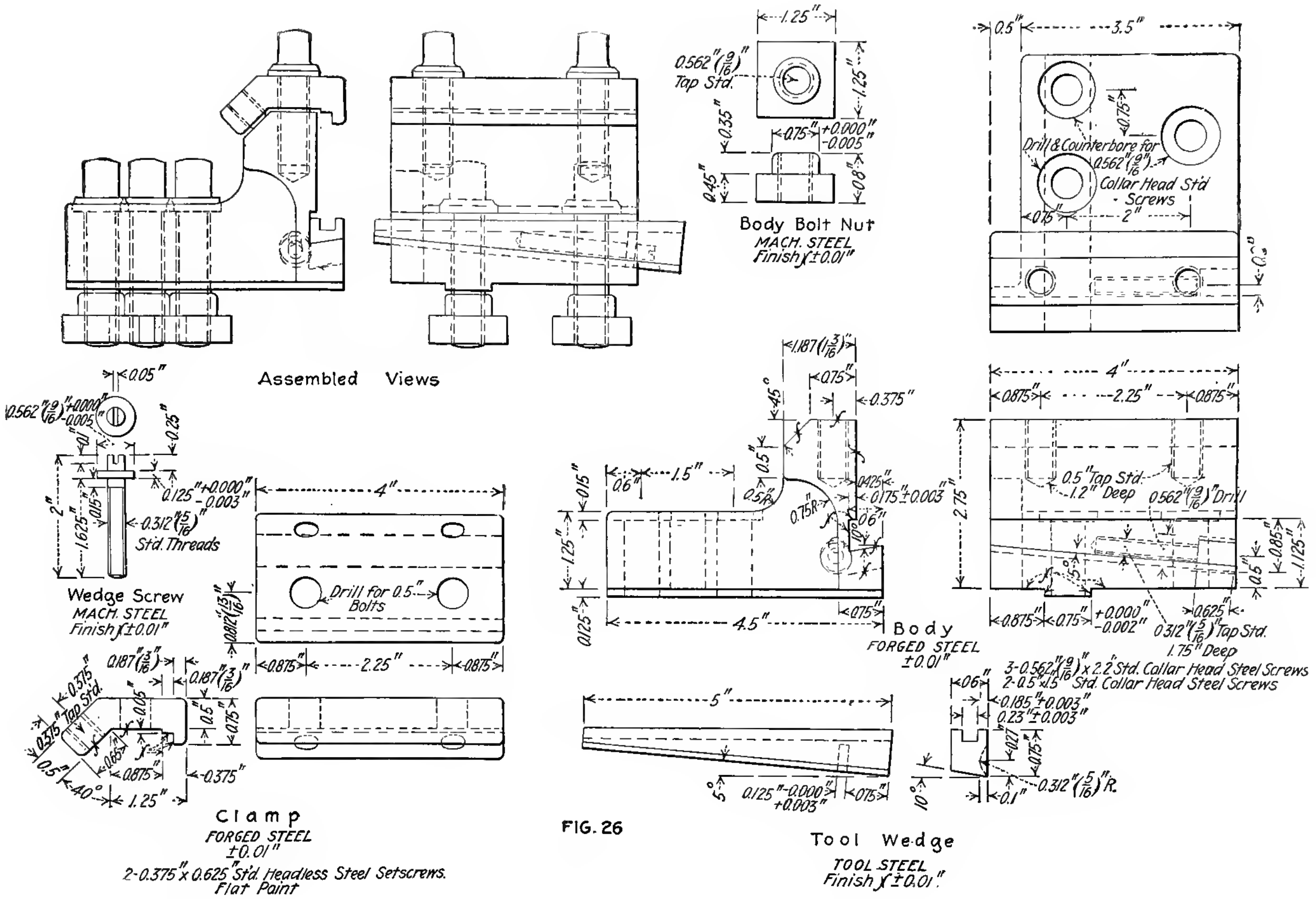


FIG. 26

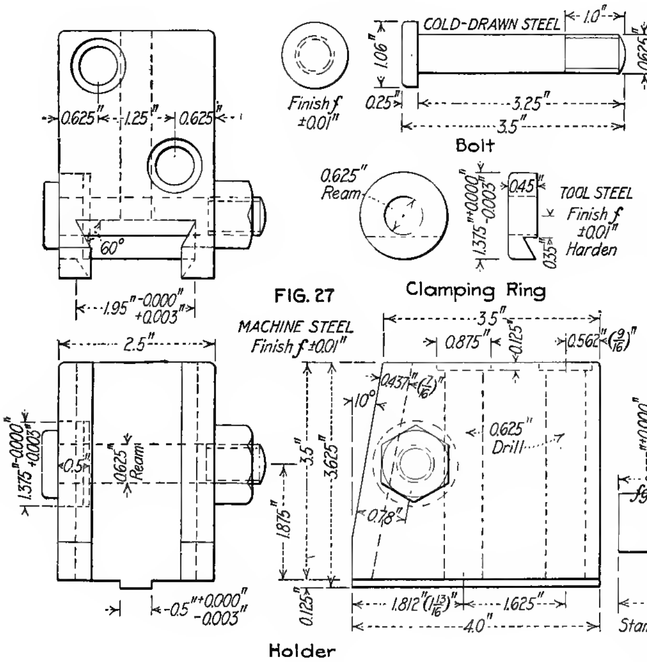


FIG. 27

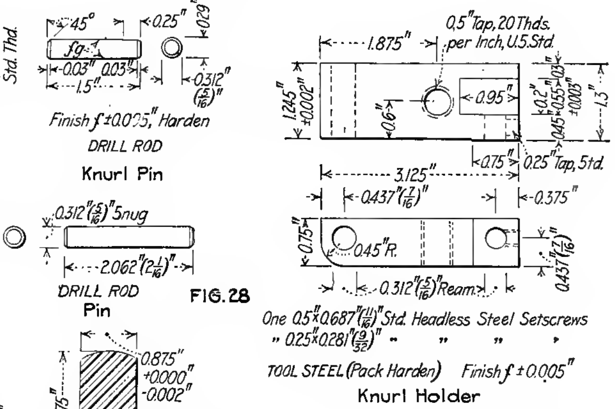


FIG. 28

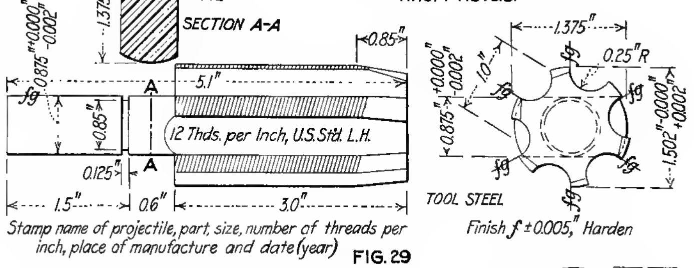


FIG. 29

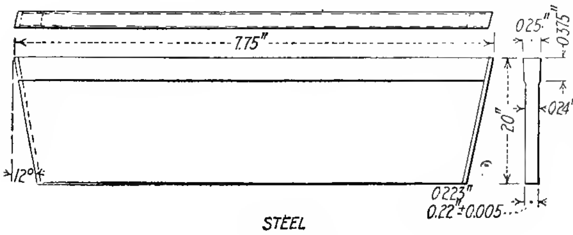


FIG. 30

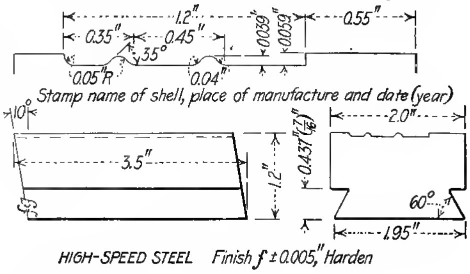


FIG. 31

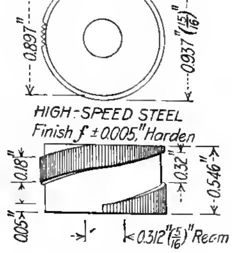


FIG. 32

OPERATION 5

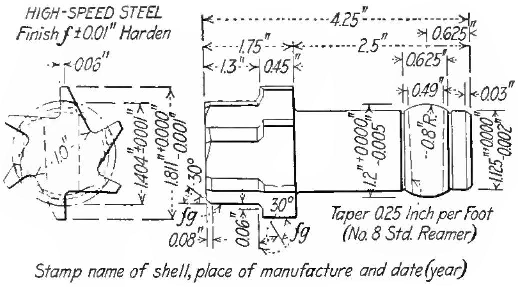


FIG. 33

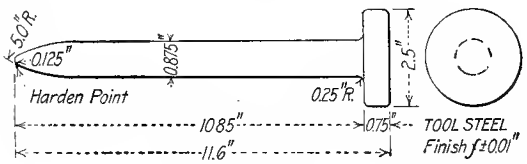
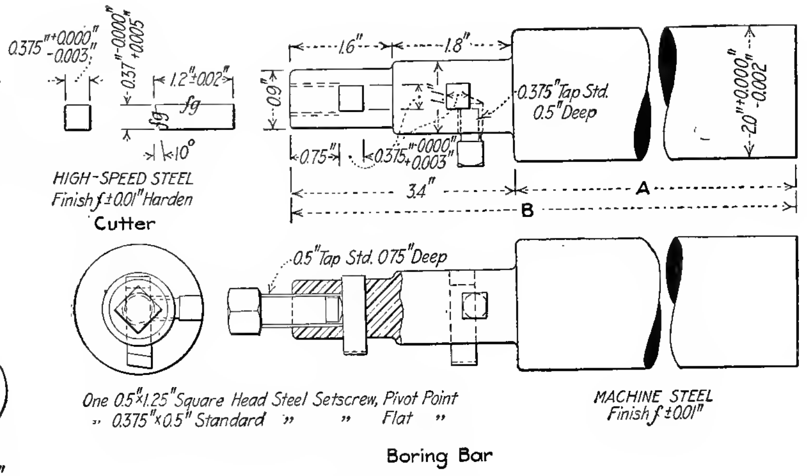


FIG. 36



A	B	NAME OF MACHINE
11.5 ±0.1	14.9 ±0.1	FOR 3.25 CLEV. AUTO. MACH.
6.25 ±0.1	9.65 ±0.1	FOR POTTER & JOHNSON

FIG. 34

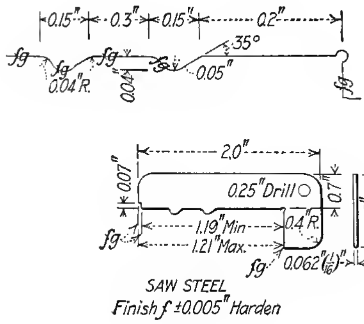


FIG. 37

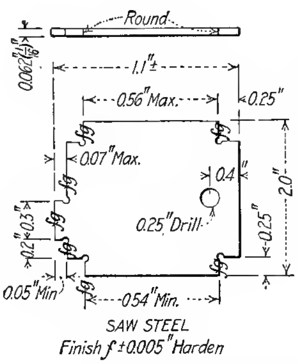
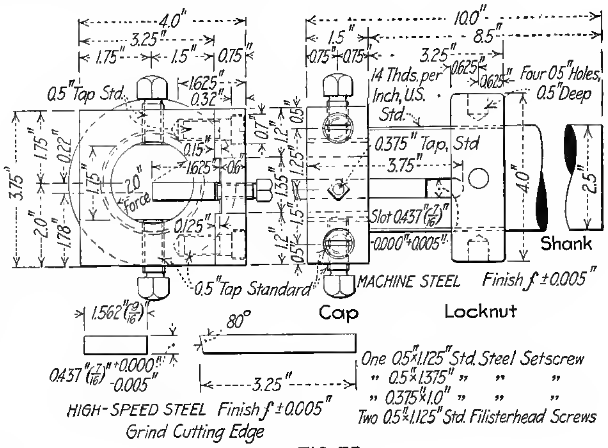


FIG. 38



OPERATION 5

FIG. 35

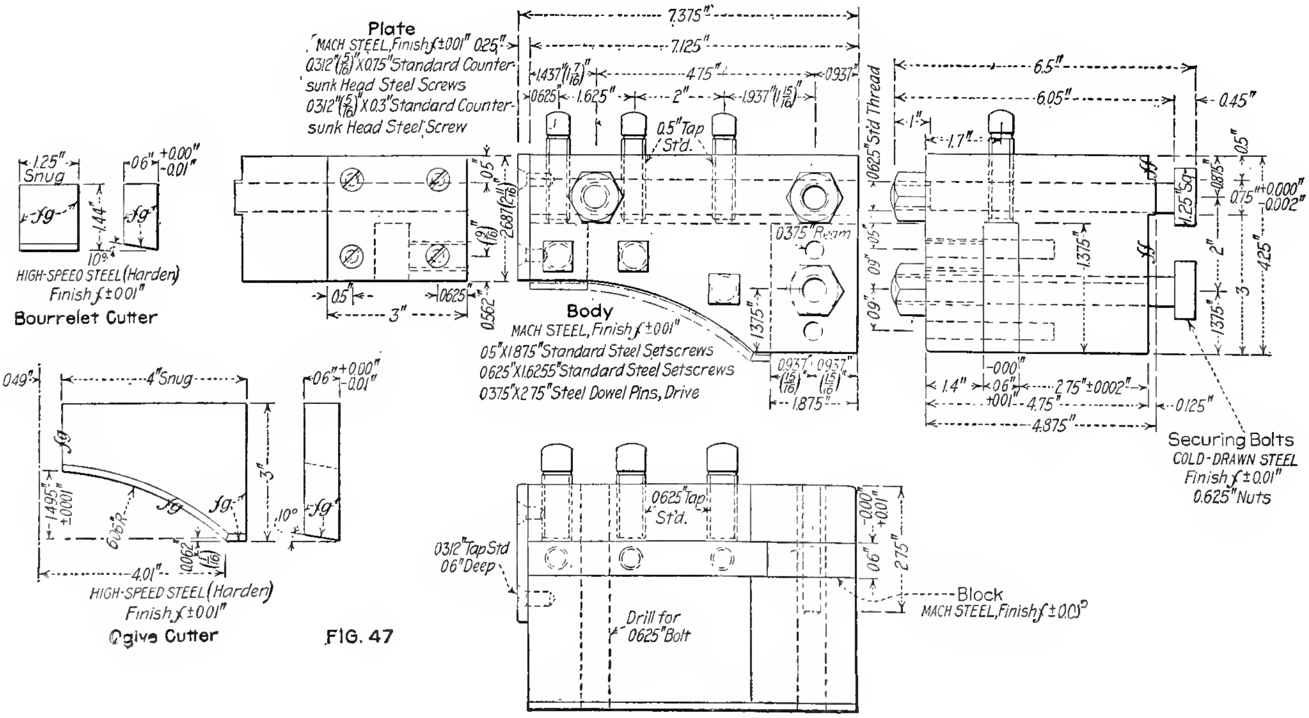


FIG. 47

OPERATION 6

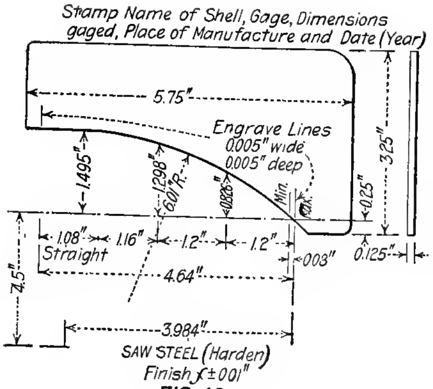


FIG. 48

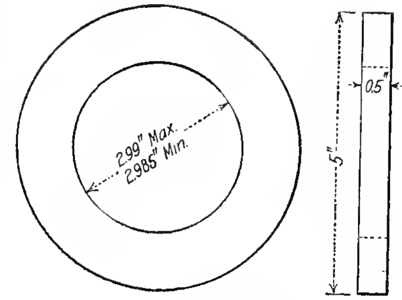


FIG. 49
OPERATION 6

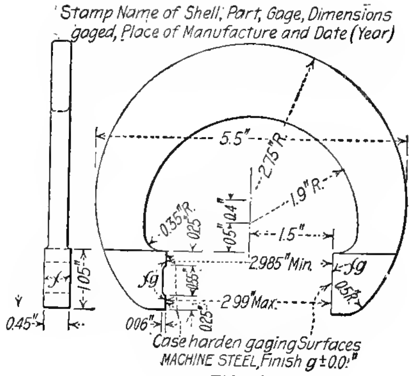


FIG. 50

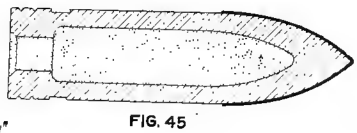


FIG. 45

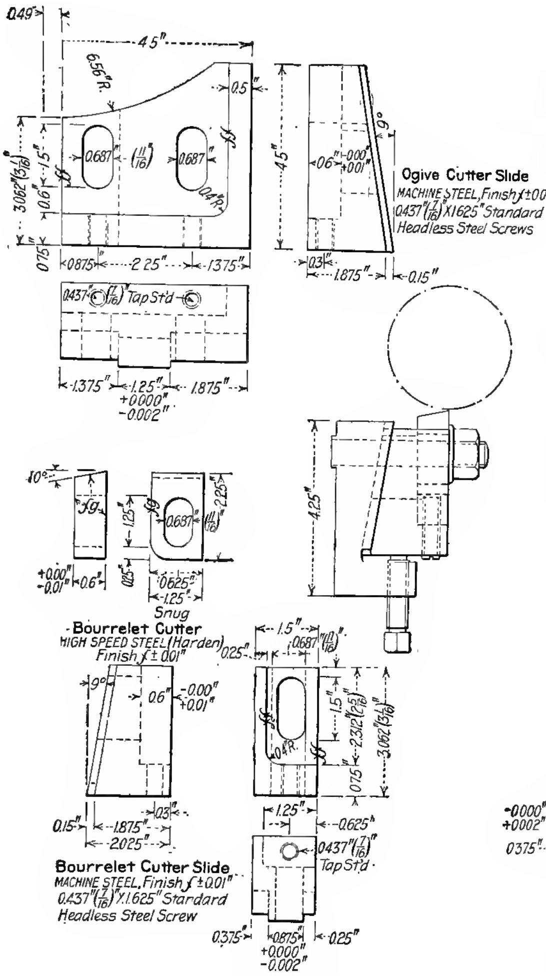
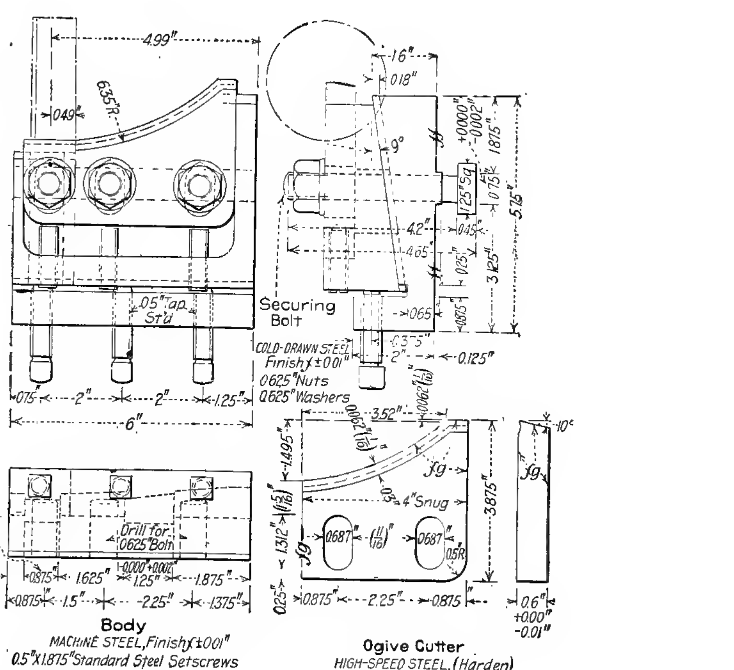



FIG. 46
OPERATION 6

23; tap holder, Fig. 24; tap-holder adapter, Fig. 25; cutoff toolholder, Fig. 26; form tool holder, Fig. 27; knurl holder, Fig. 28. Cutting Tools—Tap, Fig. 29; cutoff tool, Fig. 30; form tool for band seat and groove, Fig. 31; knurl, Fig. 32; counterbore, Fig. 33; boring tool, Fig. 34; facing tool, Fig. 35. Cut Data—80 r.p.m. Coolant—Zurn cutting oil, ¾-in. diameter stream. Average Life of Tool Between Grindings—Tap, 3 or 4 days; forming tool, 1 day; reamer, 3 or 4 days; cutoff, ½ day; other tools, 2 days. Special Fixtures—Stop in pusher tube; pusher stop, Fig. 36. Gages—Depth of cavity, Fig. 14; position of band and grooves, Fig. 37; band-seat width and depth, Fig. 38; maximum ring, rear of band, Fig. 39; minimum ring, rear of band, Fig. 39; diameter and depth of fuse-flange seat, Fig. 40; maximum thread plug, Fig. 41; minimum diameter of thread and eccentric of counterbore, Fig. 42; combination snap-band seat, Fig. 43; position and width of band seat, Fig. 44. Production—32 per 8 hr. per machine.

OPERATION 6. FINISH POINT

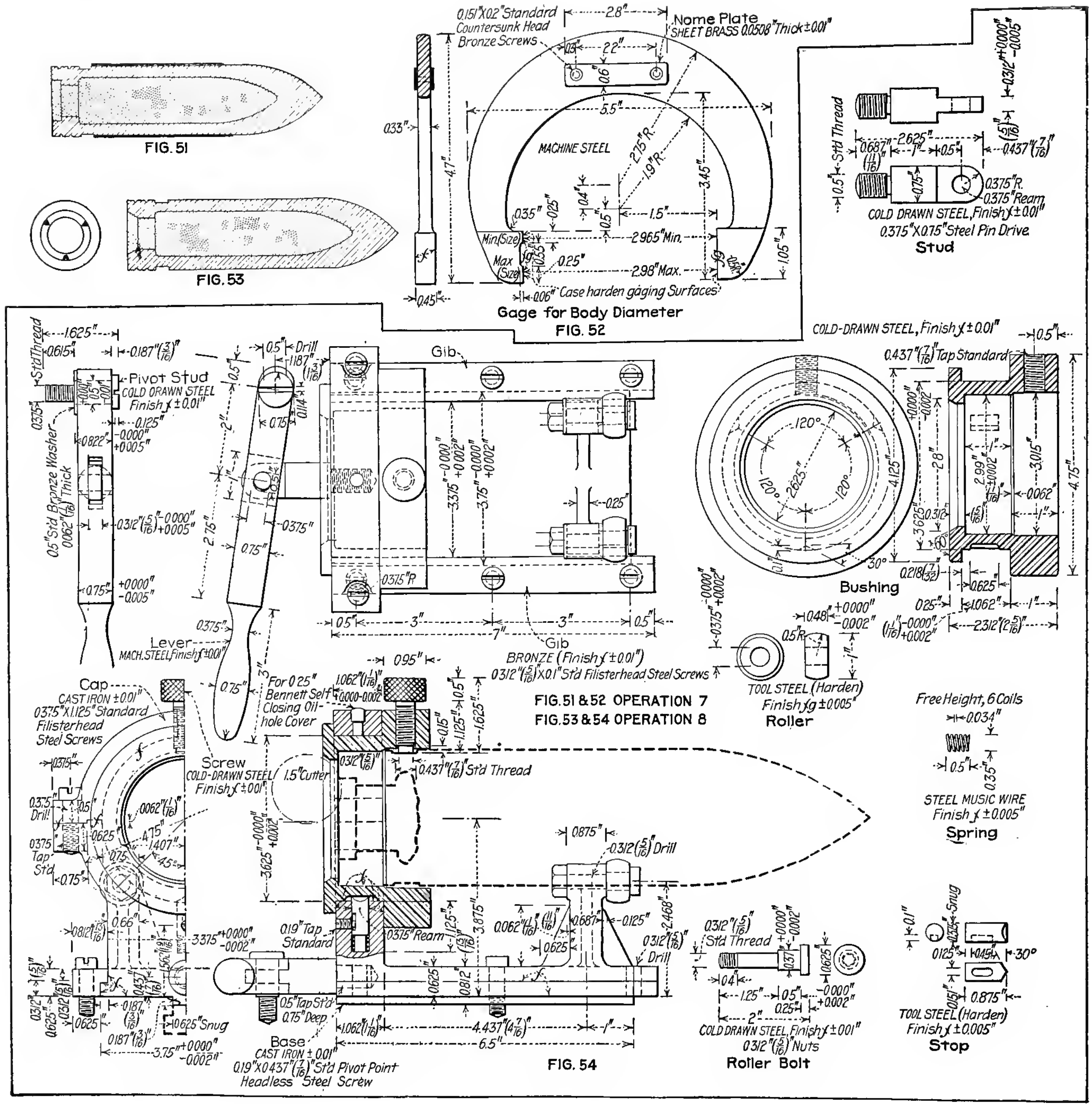
Transformation—Fig. 45. Machine Used—Cleveland 3¼-in. automatic, Fig. 7. Number of Machines per Operator—Two. Work-Holding Devices—Split chuck. Tool-Holding Devices—Roughing toolholder, Fig. 46; finishing toolholder, Fig. 47. Cutting Tools—Tool for roughing ogive, Fig. 46; tool for roughing bourrelet, Fig. 46; tool for finishing ogive, Fig. 47; tool for finishing bourrelet, Fig. 47. Number of Cuts—Two, roughing and finishing. Cut Data—50 ft. surface speed, 57 r.p.m. Coolant—Zurn cutting oil. Average Life of Tool Between Grindings—60 pieces. Special Fixtures—Pusher stop; spring stop. Gages—Profile, Fig. 48; maximum diameter of bourrelet ring, Fig. 49; minimum diameter of bourrelet ring, Fig. 49; combination snap bourrelet diameter, Fig. 50. Production—64 per 8 hr. per machine.

OPERATION 7. FINISH-TURN BODY

Transformation—Fig. 51. Machine Used—Reed 18-in. lathe, Fig. 8. Number of Operators per Machine—One. Work-Holding Devices—Universal three-jaw chuck, with extension jaws. Cutting Tools—Lathe turning tool. Number of Cuts—One. Cut Data—125 ft. surface speed; 150 r.p.m.; 0.045 in. depth of cut; 0.024 in. feed; total length of cut, 5½ in. Coolant—None. Average Life of Tool Between Grindings—20 pieces. Special Fixtures—Revolving center; center plug in spindle. Gages—Combination snap-body diameter, Fig. 52. Production—200 per 8 hr.

OPERATION 8. NOTCH BASE

Transformation—Fig. 53. Machine Used—Brown & Sharpe hand miller, Fig. 9. Number of Operators per Machine—One. Work-Holding Devices—Fixture, Fig. 54. Tool-Holding Devices—Arbor. Cutting Tools—Cutter, standard 60 deg., 2.75 in. in diameter, 0.5 in. thick, 22 teeth. Number of Cuts—Three. Cut Data—Cutter runs 370 r.p.m. Coolant—None. Gages—None. Production—600 per 8 hr.



Automatic machines like the one in Fig. 6 are used to finish-machine the base. The interior is rough-bored, counterbored, tapped and the end faced. While these operations are going on, the form tool for the band seat does its work, and the bottom of the groove is knurled with a knurling tool carried in the front tool block.

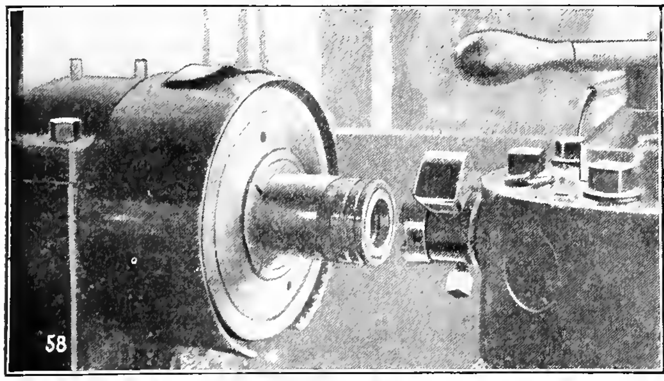


FIG. 58. ROUGHING BASE-COVER GROOVE

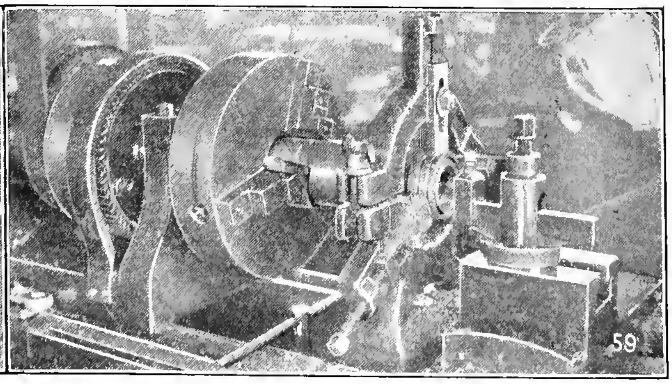
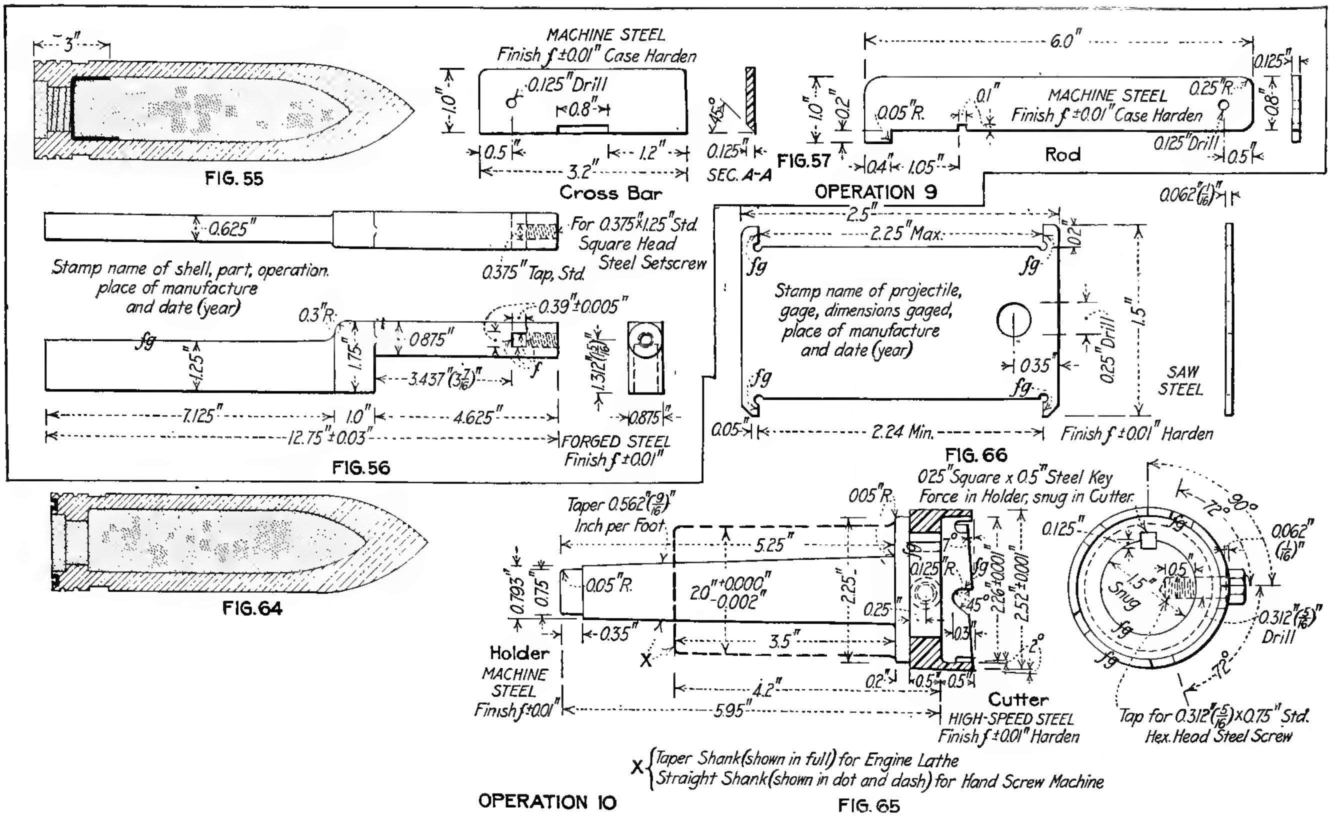


FIG. 59. FINISHING BASE-COVER GROOVE



OPERATION 9. BORE INTERIOR

Transformation—Fig. 55. Machine Used—Reed 18-in. lathe, Fig. 10. Number of Operators per Machine—One. Work-Holding Devices—Universal 10-in. three-jaw chuck; steady-rest. Tool-Holding Devices—Toolholder, boring bar, Fig. 56. Cutting Tools—Cutter for boring bar. Cut Data—150 r.p.m. Coolant—None. Average Life of Tool Between Grindings—30 pieces. Gages—Maximum and minimum length of thread, Fig. 57. Production—160 per 8 hr.

OPERATION 10. ROUGH BASE-COVER GROOVE

Transformation—Fig. 64. Machine Used—Bardons & Oliver turret lathe, Fig. 58. Number of Operators per Machine—One. Work-Holding Devices—Set collet pads, 3 in. in diameter. Tool-Holding Devices—Holder for cutter. Cutting Tools—Circular roughing cutter, Fig. 65. Cut Data—115 r.p.m., 50 ft. cutting surface speed. Coolant—None. Average Life of Tool Between Grindings—60 pieces. Gages—Diameter of groove, Fig. 66. Production—240 per 8 hr.

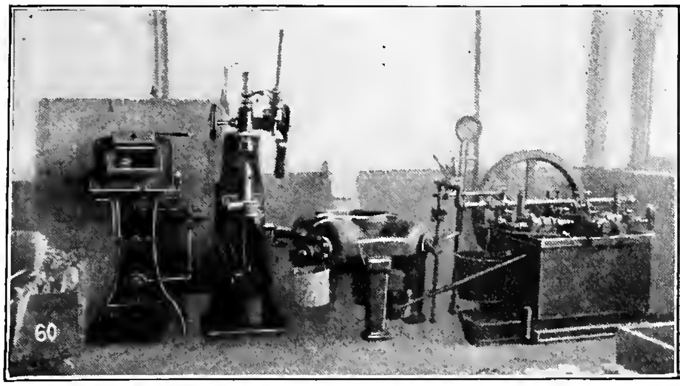


FIG. 60. BAND-ASSEMBLING GROUP

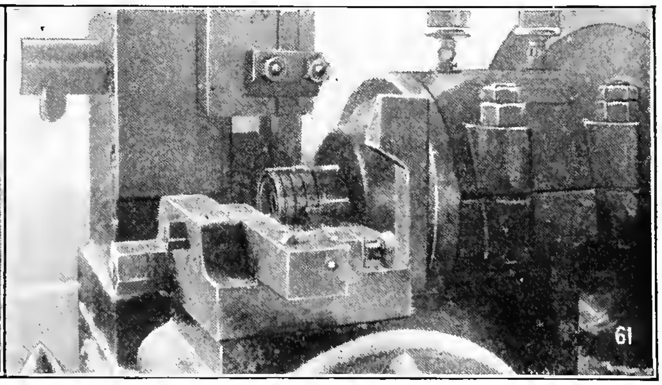


FIG. 61. SPECIAL BAND-TURNING MACHINE

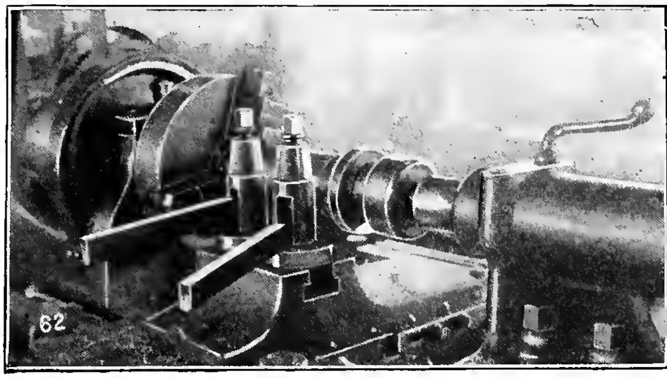


FIG. 62. TURNING BANDS IN A LATHE

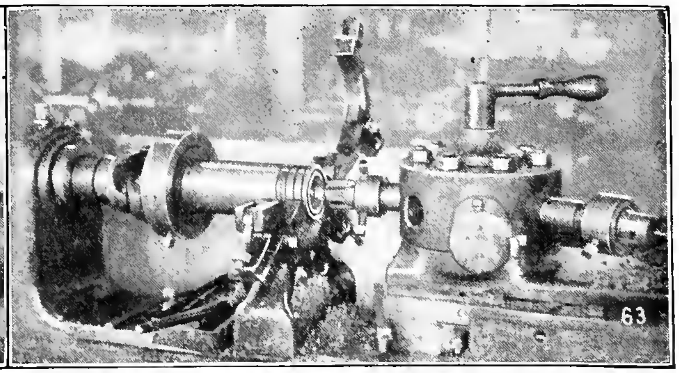


FIG. 63. RESIZING THREADS AND COUNTERBORE

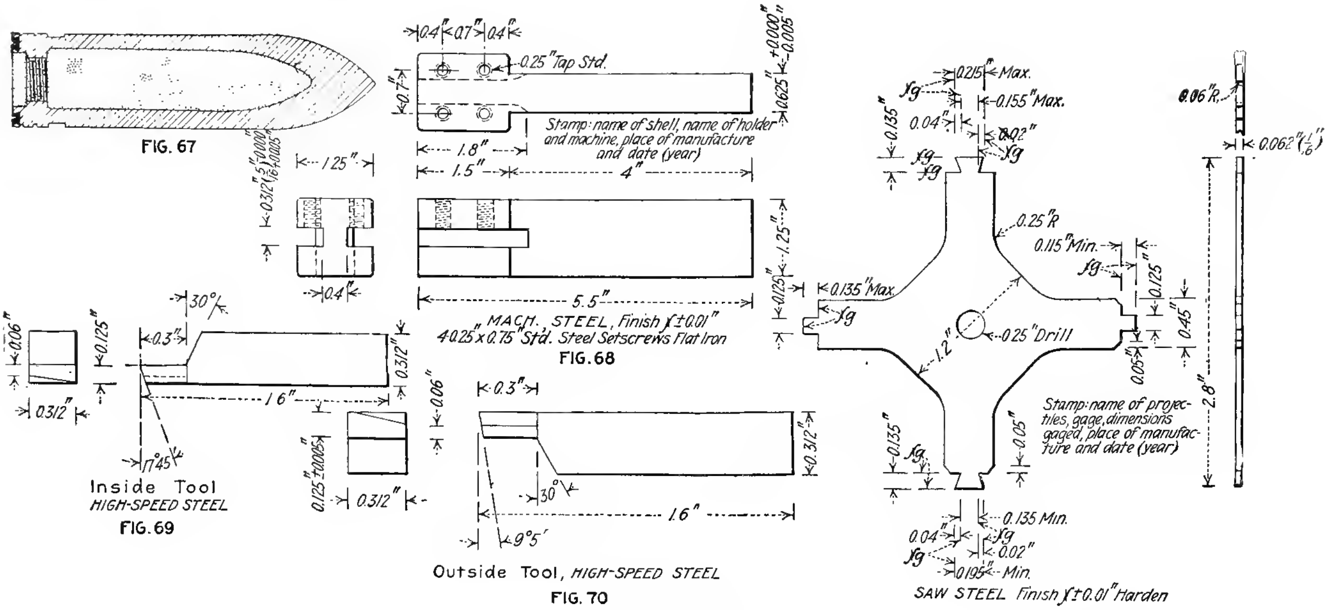


FIG. 67 FIG. 68 FIG. 69 FIG. 70 FIG. 71

OPERATION 11

From this machine the cases go to an automatic, Fig. 7, where the point and the bourrelet are roughed and finished with similar tools carried in tool blocks on opposite ends of the same cross-slide.

In finish-turning the body, it is held in a lathe just the reverse of that in the rough-turning, as shown in Fig. 8. The point rests in a centering plug in the spindle, and the base is held in a special revolving center.

The base-notching fixture is shown in Fig. 9. The shell is held in a collar into which it is locked by means of a setscrew. The outer end is supported by two rollers. As the cutter runs, the operator works the feed lever with one hand and indexes the shell with the other. These notches are cut so that the fuse can be locked in place after it is screwed home.

For the purpose of boring the interior the shell is chucked base out in a universal three-jawed chuck, with the outer end in a steadyrest, as shown in Fig. 10. A strip of tin is wrapped around the shell where the chuck jaws grip, in order to give them a better hold and not mar

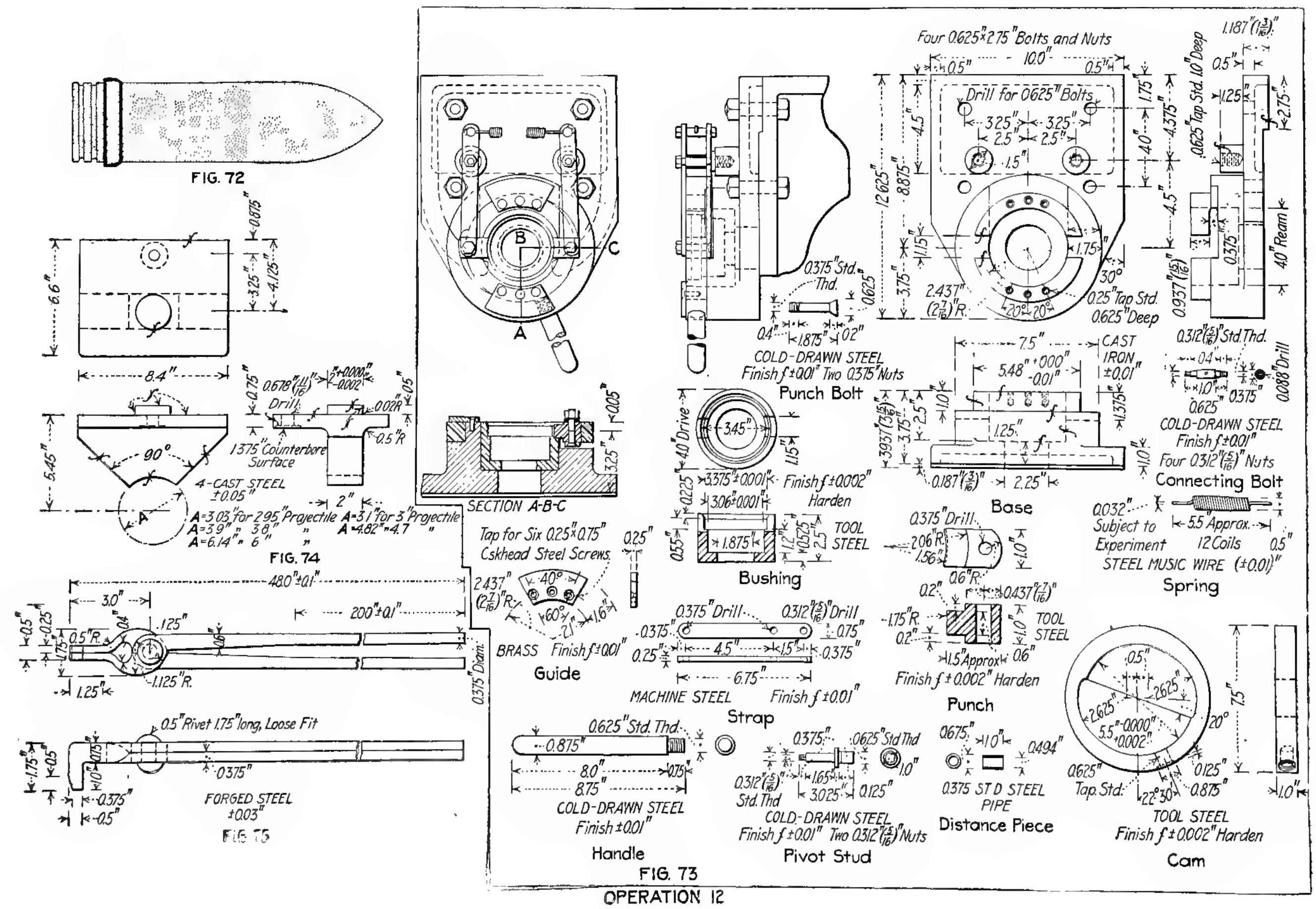
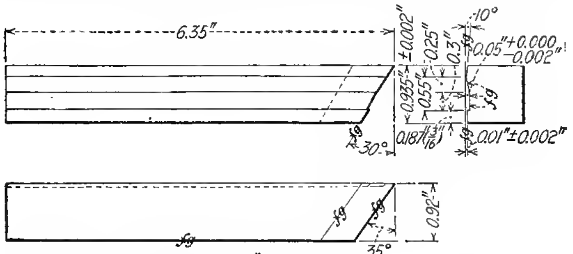


FIG. 72 FIG. 73 FIG. 74 FIG. 75

OPERATION 12

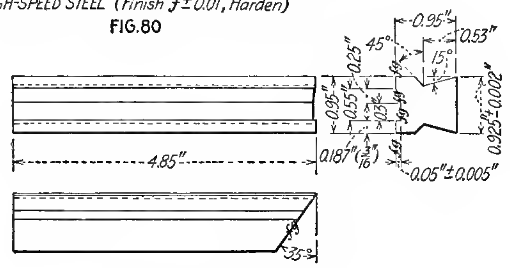
the work. The boring bar is of the ordinary type with a single-point cutter. The inside of the shell is trued up for about 3 in. from the outer end, and the length of thread shoulder is machined back from the inside to the required distance.

The base-cover groove is first roughed out with a circular cutter, Fig. 58, the shell being held in a collet



HIGH-SPEED STEEL (Finish f ± 0.01", Harden)

FIG. 80



HIGH-SPEED STEEL (Finish f ± 0.01", Harden)

FIG. 81

OPERATION 13a

chuck. From this machine the shell goes to the one shown in Fig. 59, where the groove is dovetailed and finished to correct dimensions.

The work on the copper rotating bands is the same on both the common and the shrapnel shells. The outfit used in assembling the bands to the shell case is shown in Fig. 60. The bands are placed in the furnace at the left by means of a long rod, about a dozen or more being handled at a time. The bands are heated to a low red heat; then one is seized with a pair of tongs and placed in a locating fixture in the arbor press. A shell is then set in and pressed down until the band is on a line with the groove. It is lightly pressed in and passed to the hydraulic banding press, where the band is forced securely into the groove.

OPERATION 11. FINISH BASE-COVER GROOVE

Transformation—Fig. 67. Machine Used—Flather 16-in. lathe, Fig. 59. Number of Operators per Machine—One. Work-Holding Devices—Universal lathe chuck, 9 in.; steady-rest. Tool-Holding Devices—Tool holder, Fig. 68; tool post. Cutting tools—Inside tool, Fig. 69; outside tool, Fig. 70. Cut Data—150 r.p.m. Gages—Diameter of groove, Fig. 66; depth and width of groove, Fig. 71. Production—160 per 8 hr.

OPERATION 12. ASSEMBLE BAND

Transformation—Fig. 72. Machine Used—Banding press, furnace arbor press, Fig. 60. Number of Operators per Operation—Two. Pressure Required—1300 lb. Special Fixtures—Fixture to locate band in groove, Fig. 73; set of banding dies, Fig. 74; tongs, Fig. 75; bar for bands. Gages—None. Production—150 per hr. Note—First operator puts about 40 bands on a bar and inserts in furnace; when the bands are at red heat, the operator takes one out with tongs and drops into arbor-press fixture, then drops in shell butt first, slightly compresses band and passes shell to man at banding machine, who finishes the operation.

OPERATION 13. TURN BAND ON LATHE

Transformation—Fig. 76. Machine Used—Reed 18-in. lathe, Fig. 62. Number of Operators per Machine—One. Work-Holding Devices—Universal 9-in. three-jaw chuck. Tool-Holding Devices—Two tool posts. Cutting Tools—Standard band-turning tool; standard band-facing tool; 10-in. mill file. Number of Cuts—Two, forming and facing. Cut Data—330 r.p.m., 320 ft. surface speed. Average Life of Tool Between Grindings—About ½ day. Special Fixtures—Revolving center; form, Fig. 77; form holder, Fig. 77; form follower, Fig. 77. Gages—Band profile, Fig. 78; maximum diameter of band ring, Fig. 79; minimum diameter of band ring, Fig. 79. Production—400 per 8 hr. Note—Band is profile turned, faced, and then smoothed with file.

OPERATION 13-A. TURN BAND ON SPECIAL MACHINE

Transformation—Fig. 76. Machine Used—Fig. 61. Number of Machines per Operator—One. Cutting Tools—Roughing tool, Fig. 81; finishing tool, Fig. 80; end scraper for hand use on rest. Number of Cuts—Two. Cut Data—Spindle runs 145 r.p.m.; 120 ft. per min. surface speed. Special Fixtures—Outside swing bracket is a stop; front swing bracket is hand-scraper support. Gages—Same as operation 13. Production—750 per 8 hr.

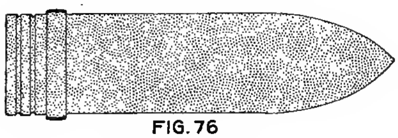
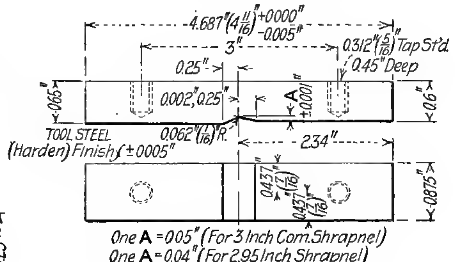


FIG. 76



Form

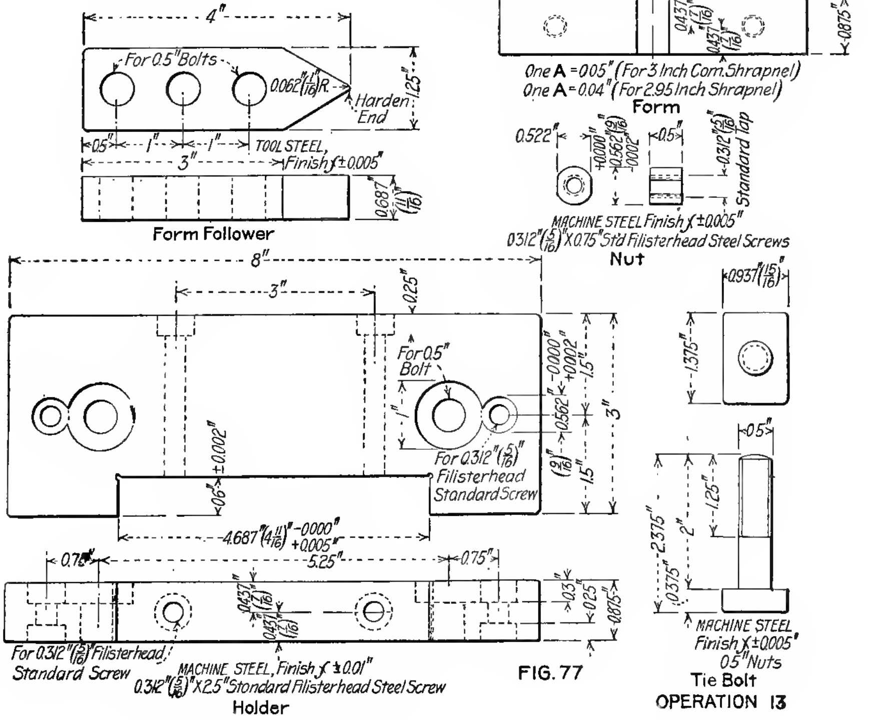


FIG. 77

OPERATION 13

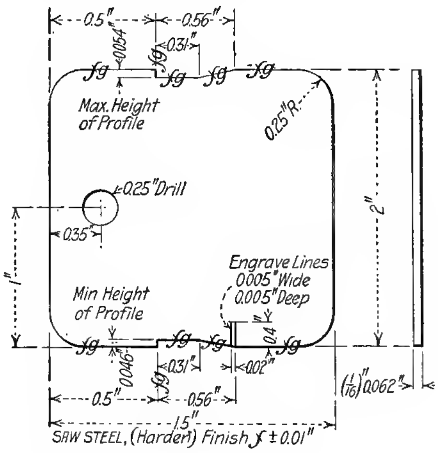


FIG. 78

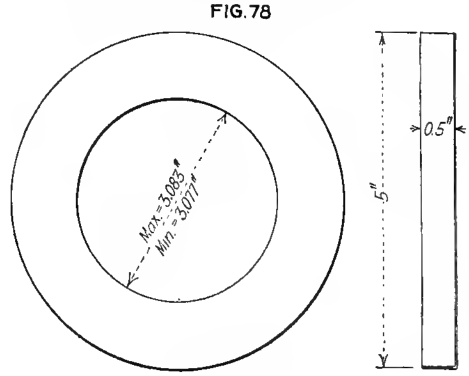


FIG. 79

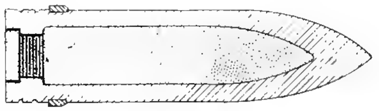


FIG. 82, OP. 14

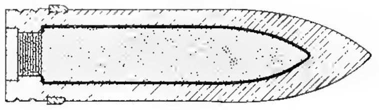


FIG. 89, OP. 15

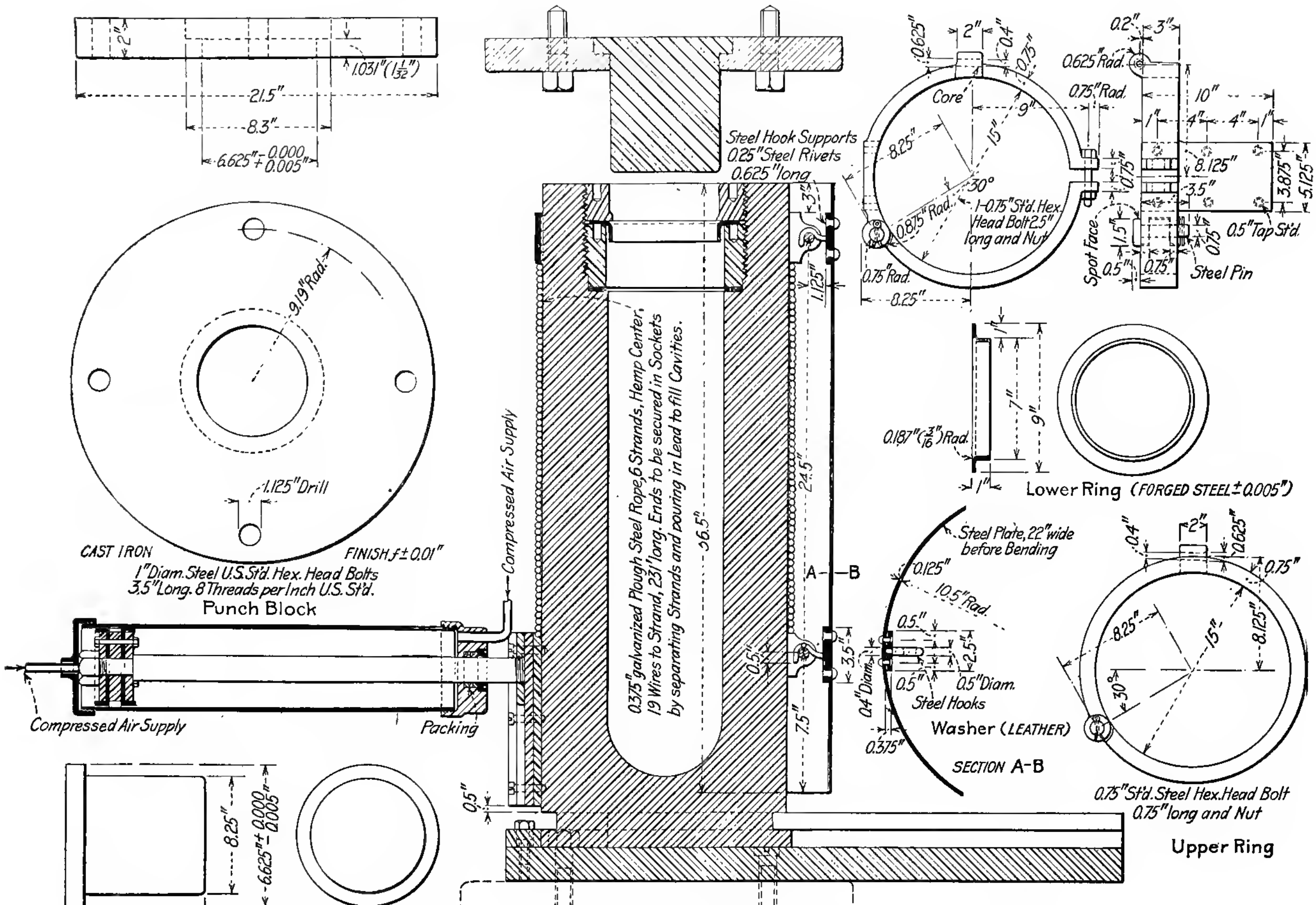


FIG. 90
OPERATION 16

OPERATION 14. RESIZE THREADS AND COUNTERBORE

Transformation — Fig. 82. Machine Used — Warner & Swasey turret lathe, Fig. 63. Number of Operators per Machine—One. Work-Holding Devices—Pot chuck; steady-rest. Cutting Tools—Boring tool; counterbore; tap. Cut Data—80 r.p.m. Coolant—Lubricated with lard oil put on with small brush. Gages—Thread gage and counterbore. Production—280 per 8 hr. Note—The shells are now inspected all over and divided into three weight classes: 12 lb. 1 oz. to 12 lb. 4 oz., 12 lb. 4 oz. to 12 lb. 8 oz., and 12 lb. 8 oz. to 12 lb. 12 oz.; these weights are then averaged in the loading process.

OPERATION 15. SANDBLAST

Transformation—Fig. 89. Number of Operators—One. Description of Operation—The operator lays a row of shells on the special bench, Fig. 83, with open ends out, pulls the hinged cover nearly down and thrusts the end of sandblast nozzle into hole in shell, sandblasting the interior to remove scale. Apparatus and Equipment Used—Paxson-Warren sandblast equipment, using No. 5½ chilled-steel shot, made by Globe Steel Co., Mansfield, Ohio; 80 lb. air pressure, with ⅜-in. diameter nozzle outlet. Gages—None. Production—3000 per 8 hr.

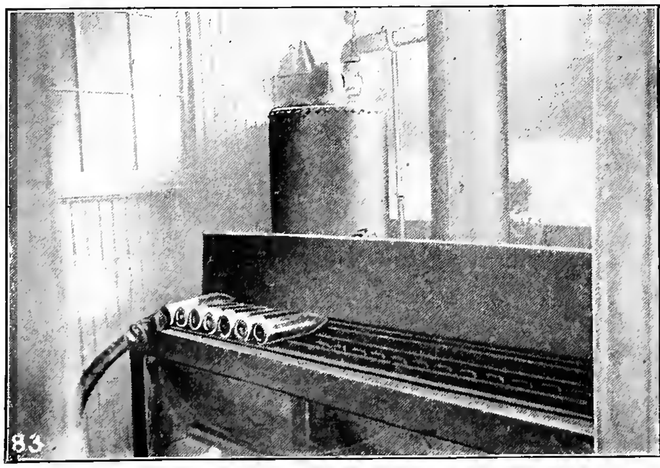


FIG. 83. SANDBLASTING APPARATUS

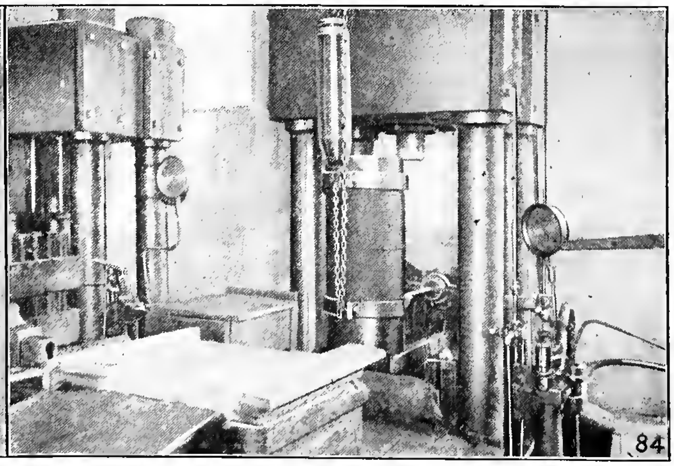


FIG. 84. PRESS FITTED FOR HYDRAULIC TESTING

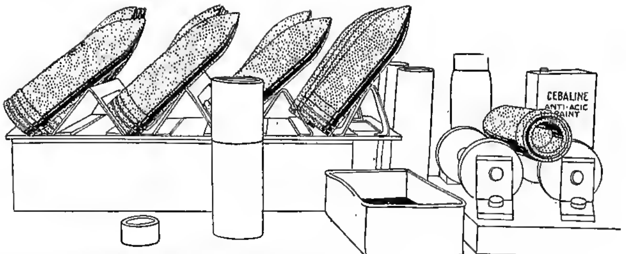


FIG. 92

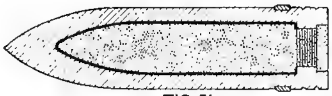


FIG. 91

OPERATION 1

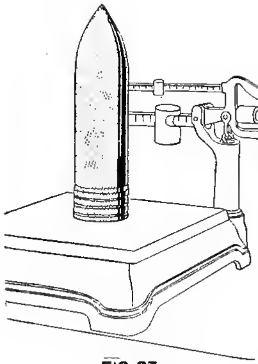


FIG. 93
OPERATION 2

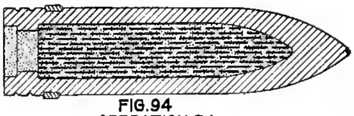


FIG. 94
OPERATION 3A

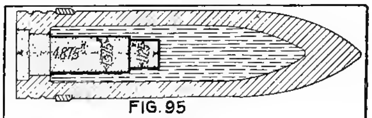


FIG. 95

OPERATION 3B

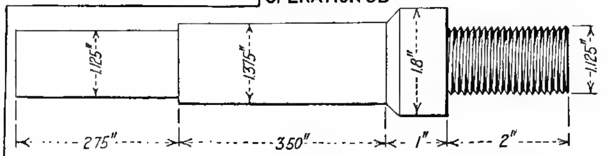


FIG. 96

OPERATION 16. HYDRAULIC TEST

Description of Operation—Case is placed in a vise, and a plug is screwed into the end to make it water-tight; the case is then placed in a special fixture, Figs. 84 and 90, in a 1500-ton heading press; the pressure applied is 350 tons, or 20,000 lb., per sq.in. Apparatus and Equipment Used—1500-ton heading press; pressure pump; testing fixture, Fig. 90; triplex chain drop; common vise. Gages—None.

OPERATION 1. PAINTING INTERIOR BY HAND

Transformation—Fig. 91. Number of Operators—Two. Description of Operation—Operator pours case full of Cebaline anti-acid paint up to threads, then pours it out and sets case in rack, base down, to drain a minute or so; second operator takes a drained case from rack and wipes end and threads with waste, and places it in truck box to dry; paint dries rapidly in about 1 hr. Apparatus and Equipment Used—Cans of paint, pans, draining rack, waste, Fig. 92. Production—1200 per 8 hr.

OPERATION 1-A. PAINTING INTERIOR WITH A SPRAY

Transformation—Fig. 91. Number of Operators—One. Description of Operation—Using the spraying apparatus, Fig. 85, the operator thrusts the nozzle inside a shell, presses the valve lever and sprays the inside to the threads; he then shuts the valve and withdraws nozzle. Apparatus and Equipment Used—Eureka spray and Cebaline anti-acid paint. Production—10 per min.

OPERATION 2. WEIGHING

Number of Operators—One. Description of Operation—Operator places case on scale platform, weighs it and chalks weight on side, Fig. 93, then places piece in tote box, ready for elevating truck. Apparatus and Equipment Used—Small platform scale. Production—1600 per day.

OPERATION 3-A. FILLING WITH TRINITROTOLUOL

Transformation—Fig. 94. Number of Operators—Three in gang for filling and compressing. Description of Operation—A complete fuse and base cover are kept on platform of scale; first operator weighs out enough trinitrotoluol in a tin container to bring total weight of case, fuse and base cover to 15 lb.; he then pours the trinitrotoluol into case on holding

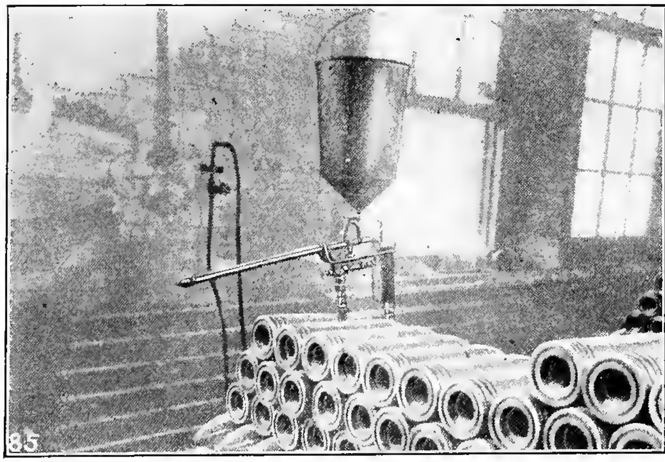


FIG. 85. INTERIOR PAINT-SPRAYING OUTFIT

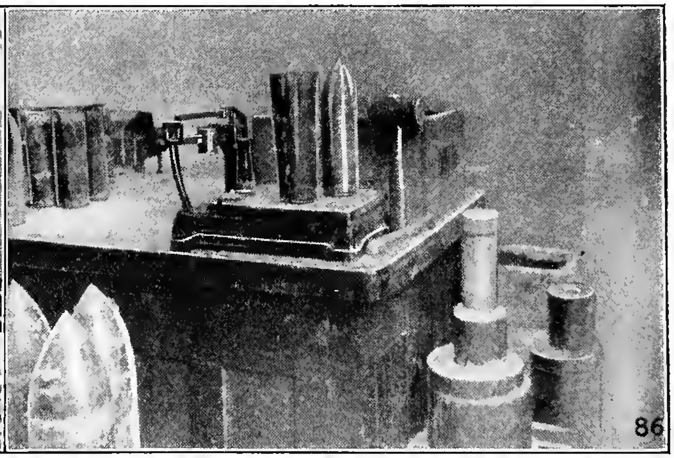


FIG. 86. FILLING WITH TRINITROTOLUOL

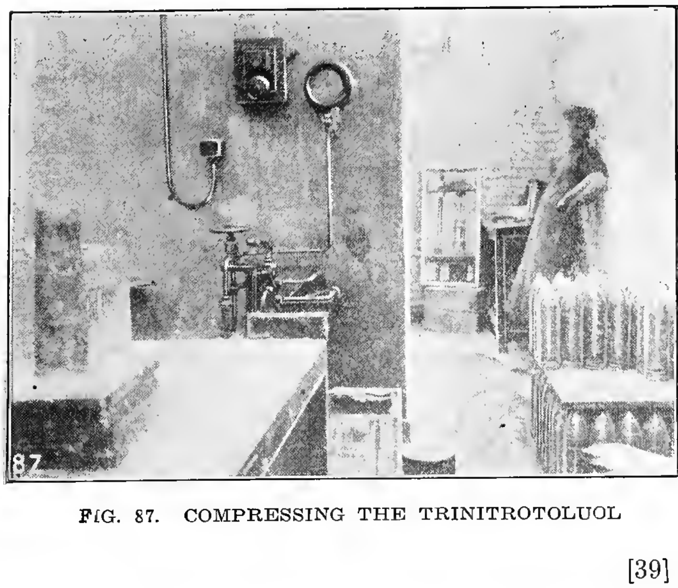


FIG. 87. COMPRESSING THE TRINITROTOLUOL

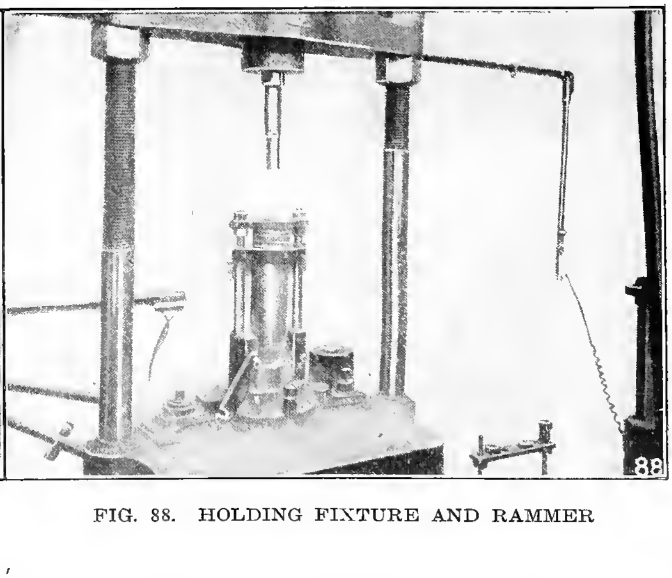


FIG. 88. HOLDING FIXTURE AND RAMMER

block and rams down powder with brass rammer and heavy rawhide hammer; load is then compressed in hydraulic press; in case of a light-weight shell, more powder is added and again compressed, in some cases several compressions being necessary to get enough powder in to bring weight high enough. Apparatus and Equipment Used—Small platform scale, rawhide hammers, brass rammer, holding blocks, Fig. 86. Production—320 per day.

OPERATION 3-B. COMPRESSING THE TRINITROTOLUOL

Transformation—Fig. 95. Machine Used—Riehle 40,000-lb. hydraulic press. Number of Operators in Gang—Three. Punches and Punch Holders—Bronze ramming punch, Fig. 96.

OPERATION 4. REAMING FOR FUSE CASE

Transformations—Figs. 103 and 104. Machine Used—Small lathe, Fig. 97. Number of Machines per Operator—One. Cutting Tools—Reamer, Fig. 105. Gages—Stop collar on reamer. Production—1200 per 8 hr.

OPERATION 5. CLEANING THREADS AND COUNTERBORE

Number of Operators—One. Description of Operation—Operator places case on revolving fixture, Fig. 98; cleans threads and counterbore with hook tool and scraper; then wipes with waste soaked in benzol and finally wipes with dry waste. Apparatus and Equipment Used—Fixture, Fig. 107. Production—350 per 8-hr. day.

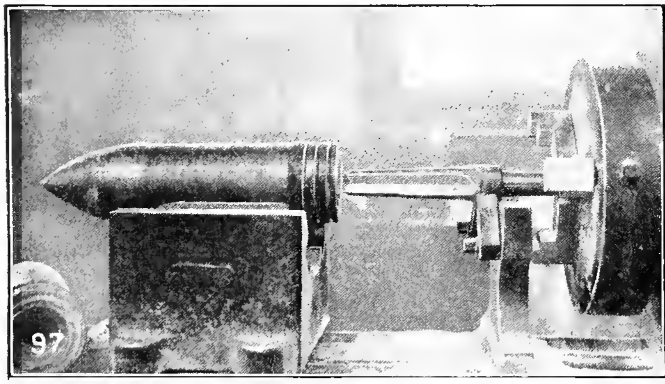


FIG. 97. REAMING FOR FUSE CASE

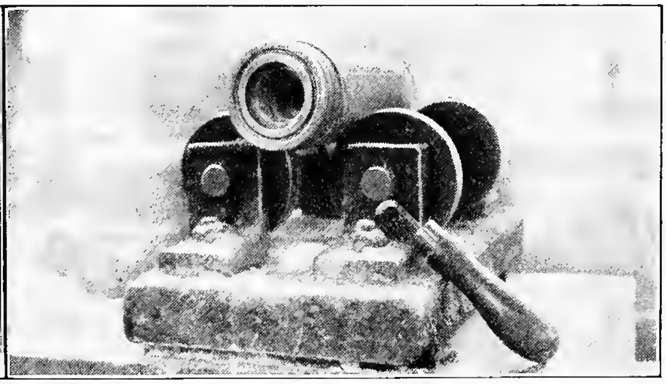


FIG. 98. CLEANING THE THREADS

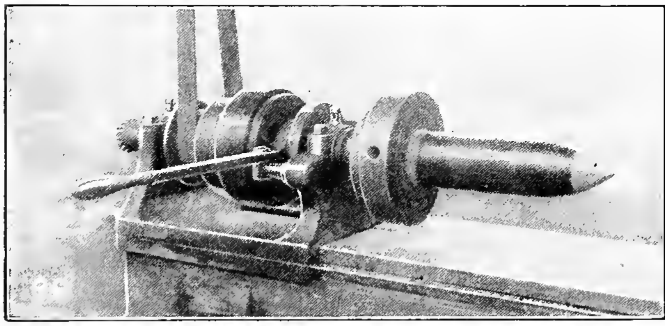


FIG. 99. PAINTING THE OUTSIDE

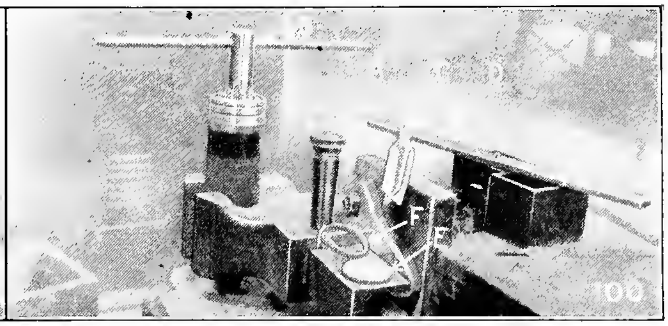


FIG. 100. PUTTING IN FUSE AND BASE COVER

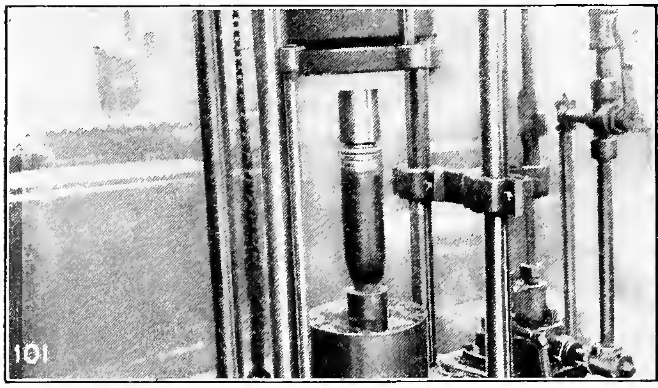


FIG. 101. PRESSING ON BASE COVER WITH TRACER

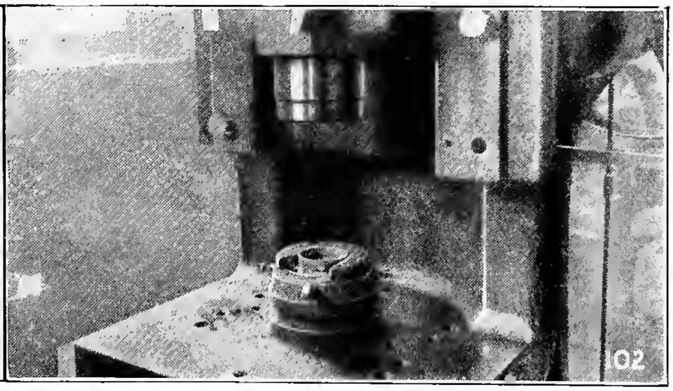


FIG. 102. PLANISHING THE BANDS

Description of Operation—Second operator takes filled case and puts in hydraulic press; third operator then operates valve levers from outside of "bombproof," as soon as second operator is outside, and watches operation of press ram from a mirror placed as shown in Fig. 87; about 30 sec. is required for ram stroke each way; the punch is forced in 4⅞ in. from end of case, which is 4¾ in. + ⅛-in. allowance for end of detonator fuse. Pressure Required—Pressure varies according to amount of trinitrotoluol needed to bring weight of case to 15 lb. ± 2½ oz.; on cases weighing 12 lb. 2 oz., about 24,000 lb. pressure is required; from 12 lb. 4 oz. to 12 lb. 6 oz., 14,000 lb.; 12 lb. 14 oz., 8000 lb.; as a rule, 12-lb. 2-oz. cases are considered too light, as the pressure required to force in enough trinitrotoluol makes the work too dangerous. Special Fixtures—Case-holding fixture, Fig. 88. Production—320 per day. Note—The bombproofs in which the presses are placed are of concrete about 7 ft. wide, 9 ft. long, 10 ft. high, with walls 1 ft. thick.

OPERATION 6. PAINTING OUTSIDE

Transformation—Fig. 108. Number of Operators—One. Description of Operation—Operator chucks case in small lathe, Fig. 99, fitted with split centering chuck, pushing butt end in as far as the rotating band will allow; he then starts lathe, which runs 240 r.p.m., and applies paint with wide brushes. Apparatus and Equipment Used—Black, red and gray paint; three brushes to suit. Production—350 per day.

OPERATION 7-A. PUTTING IN FUSE (WITHOUT NIGHT TRACER)

Transformation—Fig. 109. Number of Operators—One. Description of Operation—Operator puts case in vise and sees that reamed cavity is clean and deep enough; if not, he puts in a reamer and pounds and rotates it until of the desired size; if the threads are tight, he retaps them; the threads of the detonating fuse are greased with cosmoline, and it is

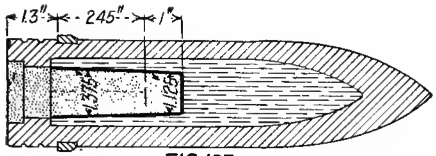


FIG. 103

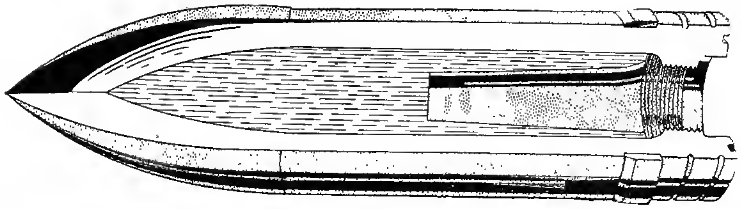
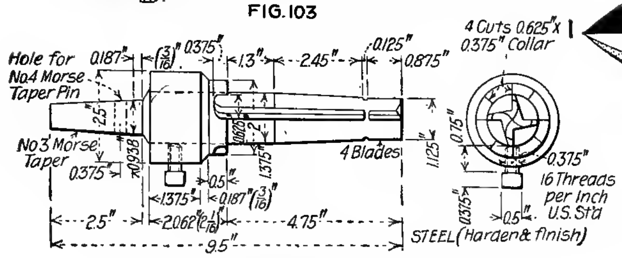


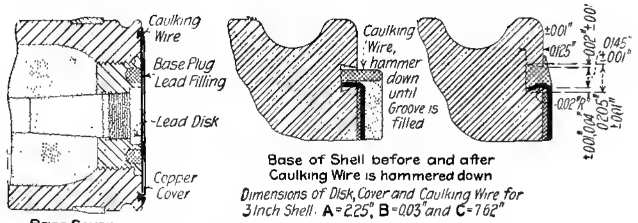
FIG. 104



OPERATION 4

Reamer with Stop
(For Medium Caliber Base-detonating Fuse)
FIG. 105

screwed home with a long spanner wrench, then locked in place by means of a punch used at the three milled notches in the case; the spanner holes are filled by pounding in lead slugs, Fig. 110; lead disk and base cover are put on; lead calking washer is put in base-cover groove and pounded down all around, securely holding base cover in place, Fig. 111. Apparatus and Equipment Used—Common vise, reamer, bronze hammer, tap, spanner wrench, cosmoline, complete detonator fuse, base cover, lead ring, boxes of lead slugs, Fig. 100. Production—160 per day.



Base Cover

Base of Shell before and after Caulking Wire is hammered down

Dimensions of Disk, Cover and Caulking Wire for 3 Inch Shell. A = 2.25", B = 0.03" and C = 7.62"

FIG. 109

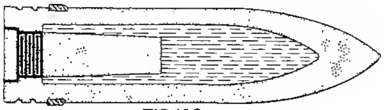
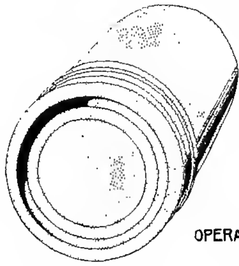


FIG. 106



OPERATION 7A

FIG. 110

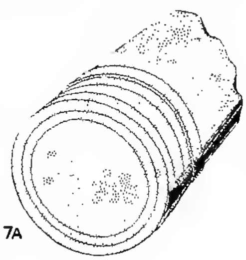
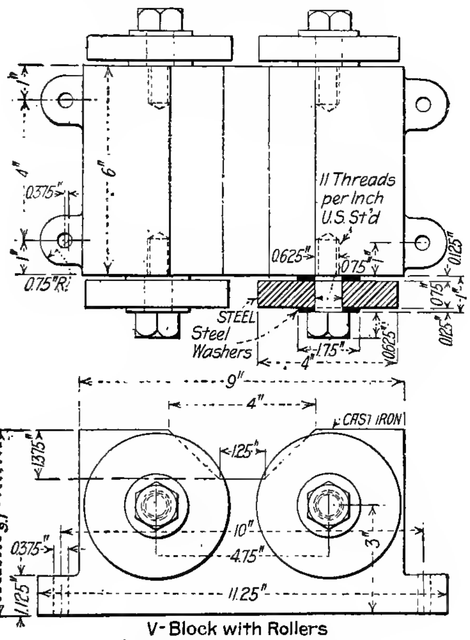


FIG. 111



V-Block with Rollers
(For cleaning Fuse-seat Thread)
FIG. 107
OPERATION 5

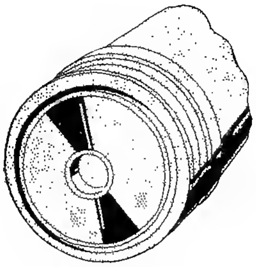


FIG. 112 A

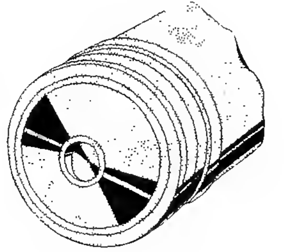
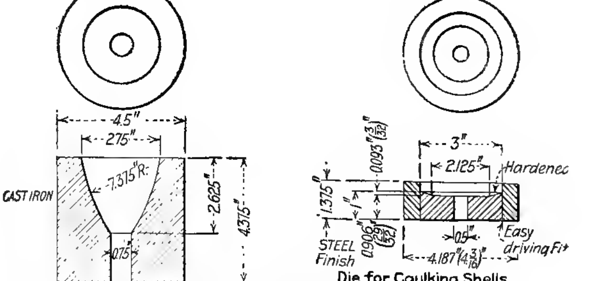


FIG. 112 B



Solid Punch for Caulking Shells

Die for Caulking Shells

FIG. 113
OPERATION 7B

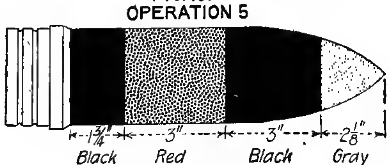


FIG. 108
OPERATION 6

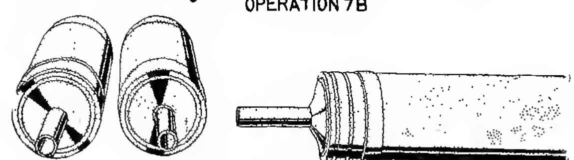


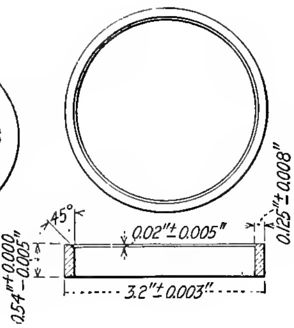
FIG. 114
OPERATION 7C

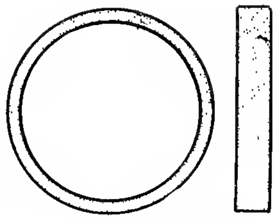
OPERATION 7-B. PRESSING ON BASE COVER WITH NIGHT TRACER

Transformation—Figs. 112-A and 112-B. Machine Used—Watson-Stillman hydraulic press, Fig. 101. Number of Operators—Two. Description of Operation—The base detonating fuse is put in as in operation 7-A, then piece is taken by this gang; the helper puts on lead disk and night-tracer base cover and presses in the calking ring; press operator then takes it and presses down the ring, as shown. Pressure Required—About 2000 lb. Special Fixtures—Point-holding block; cover-ring pressing block, Fig. 113. Production—300 per 8-hr day.

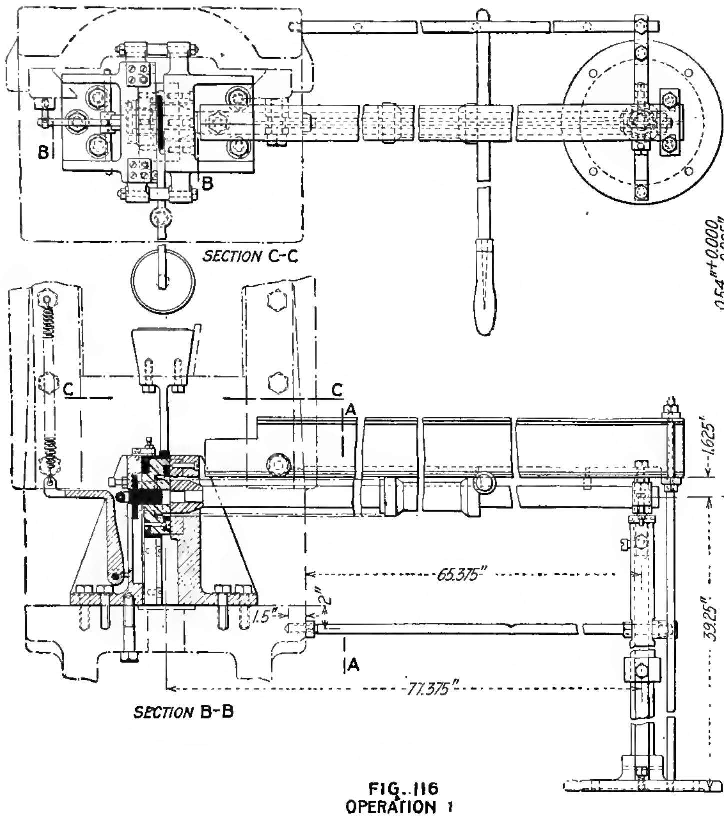
OPERATION 7-C. SCREWING IN NIGHT TRACER

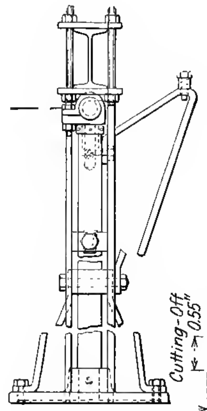
Transformation—Fig. 114. Number of Operators—One. Description of Operation—Operator clamps a night tracer in a vise and, holding the case in his hands, screws it on the tracer. Apparatus and Equipment Used—Common vise.





BAND (Copper Tubing)
FIG. 115





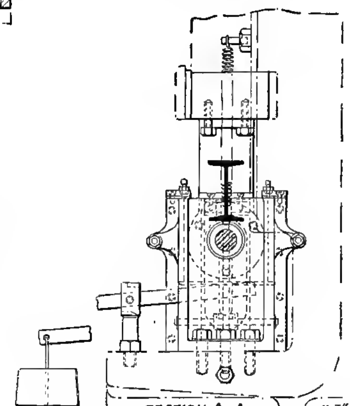
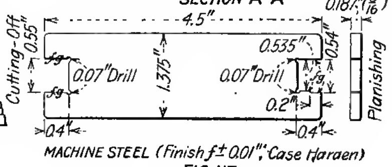


FIG. 116
OPERATION 1



MACHINE STEEL (Finish f ± 0.01", Case Harden)
FIG. 117

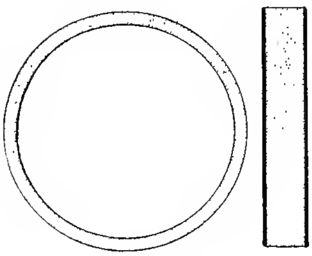
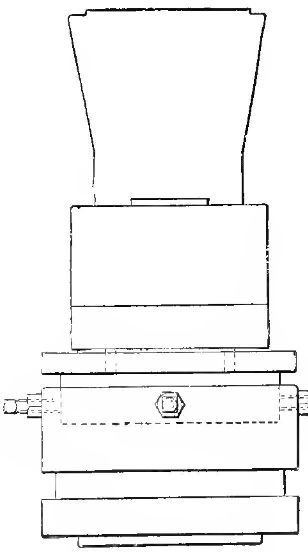
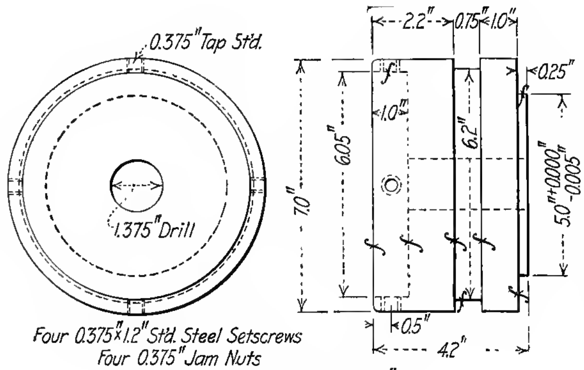
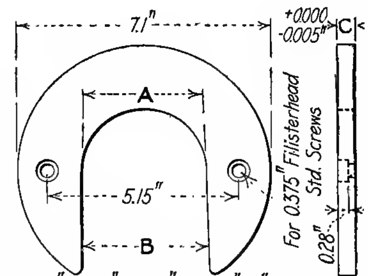


FIG. 118

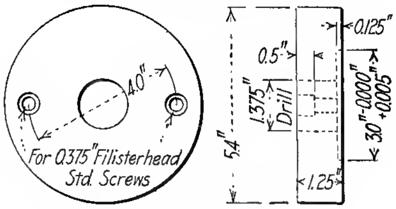




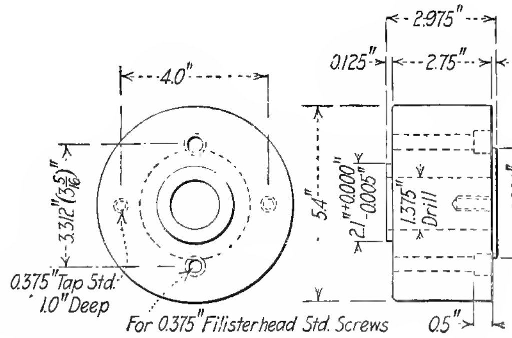
MACHINE STEEL ±0.01"
Lower Punch Holder



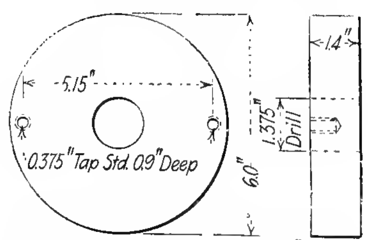
A=3.35" B=3.5" C=0.51" for 2.95" & 3" Projectiles
A=4.25" B=4.4" C=0.66" for 3.8" Projectiles
COLD-DRAWN STEEL Finish f ± 0.01"
Band Form



MACHINE STEEL Finish f ± 0.01" Harden
Lower Punch

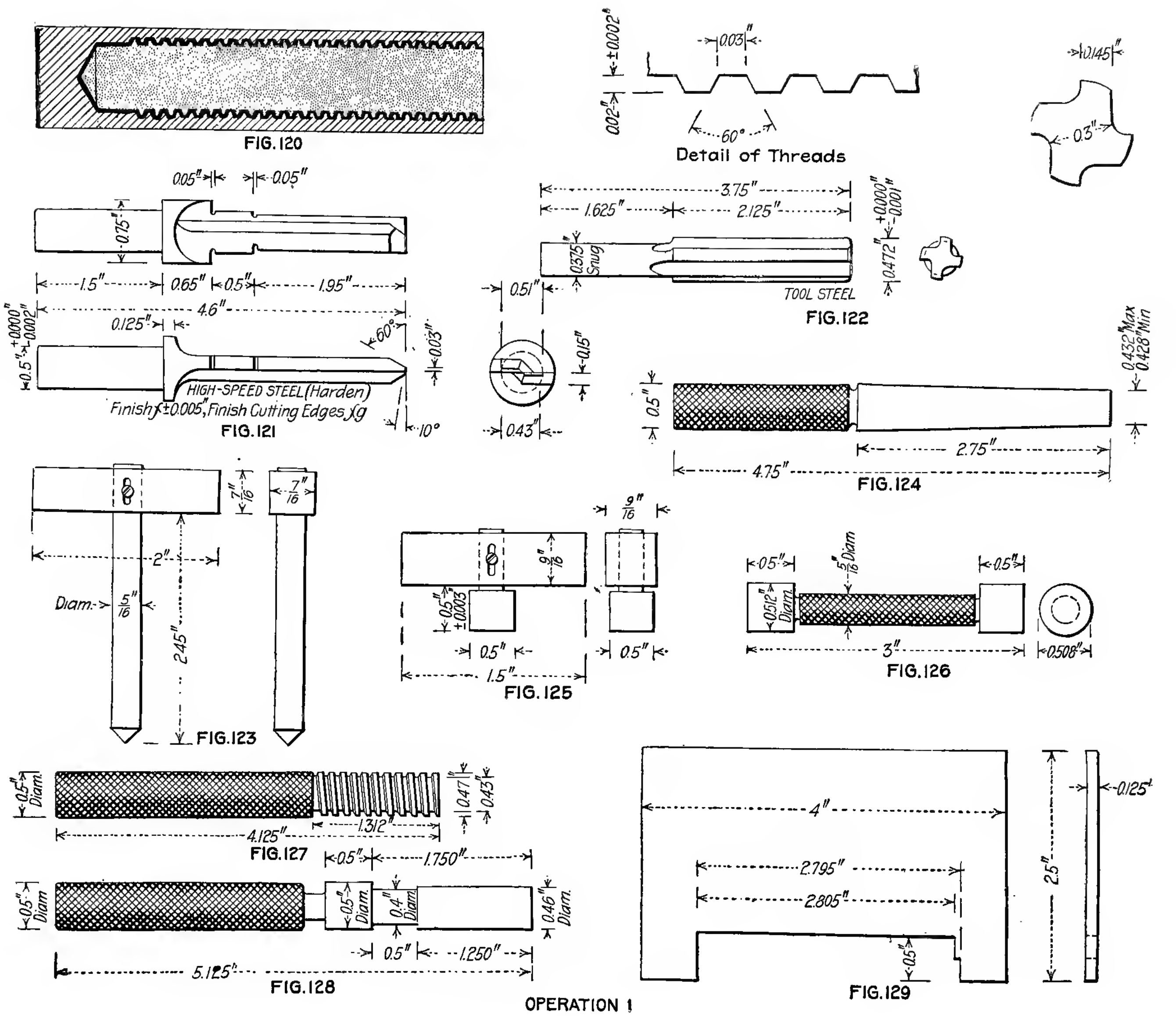


MACHINE STEEL
Finish f ± 0.01"
Upper Punch Holder



MACHINE STEEL Finish f ± 0.01" Harden
Upper Punch

FIG. 119
OPERATION 5



OPERATION 1

OPERATION 1. CUT FROM TUBING (COPPER)

Transformation—Fig. 115. Machine Used—15,000-lb. adjustable-stroke crank press. Number of Operators per Machine—One. Special Fixtures—Shearing attachment, Fig. 116. Gages—Maximum and minimum width, Fig. 117. Production—3000 in 8-hr. day.

OPERATION 2. ANNEAL

Number of Operators—Three. Description of Operation—Bands are placed 1000 at a time in a large pan; four of these pans are put into furnace and heated for ¾ hr. to about 1200 deg. F.; they are then placed on trucks and run out into the air to cool. Apparatus and Equipment Used—Annealing pans, truck, furnace. Production—40,000 per 8-hr. day.

OPERATION 3. PICKLE

Number of Operators—Two. Description of Operation—Bands are put in baskets and pickled in 1 part vitriol and 6 parts water until scale is removed and pieces are brightened. Production—8000 per 8 hr.

OPERATION 4. WASH

Number of Operators—Two. Description of Operation—Washed well in cold water to remove pickle solution. Apparatus and Equipment Used—Basket and tank. Production—8000 per day. Note—Pickling and washing tanks are side by side, and a basket of pickled bands is simply hoisted out of one tank into the other and, after washing, suspended a short time to drain.

OPERATION 5. PLANISHING

Transformation—Fig. 118. Machine Used—15,000 lb. adjustable-stroke crank press, Fig. 102. Number of Operators per Machine—One. Special Fixtures—Fig. 119. Gages—Maximum and minimum, Fig. 117. Production—3000 per 8 hr.

OPERATION 1. DRILLING, COUNTERBORING, TAPPING

Transformation — Fig. 120. Machine Used — Brown & Sharpe automatic. Number of Machines per Operator—Three. Cutting Tools—½-in. twist drill (drills in $\frac{15}{32}$ in. for counterbore); $\frac{13}{32}$-in. twist drill; combination reamer and counterbore, Fig. 121; tap, Fig. 122; circle chamfering tool, 3 in. in diameter; circle cutoff tool, 3 in. in diameter by 0.10 in. thick. Cut Data —1200 r.p.m. for all but tapping; 530 r.p.m. for tapping. Coolant—Zurn cutting oil. Gages—Depth of drilled hole, Fig. 123; maximum and minimum reamed diameter plugs, Fig. 124; depth of counterbore feeler, Fig. 125; maximum and minimum diameter counterbore, Fig. 126; diameter of thread, Fig. 127; depth of thread, Fig. 128; maximum and minimum length, Fig. 129. Production—800 per 8-hr. day. Note—Made from hard-rolled brass rod, ⅝-in. diameter ±0.005; tools are used in order given.

Turning of the bands is done on either a special machine or a lathe, as shown in Figs. 61 and 62. On the lathe two tools are used in the same slide. One roughs off and edges the band, and the other finishes it, being guided by means of a profile block and follower at the back. A final dressing is given with a mill file.

On the special machine, the band is roughed off with one tool and then finished with a form tool. A tool rest is then dropped in place and the band smoothed up with an end scraper. Following this the threads and counterbore are carefully sized, as shown in Fig. 63. This operation, however, is not always necessary and is only done when needed.

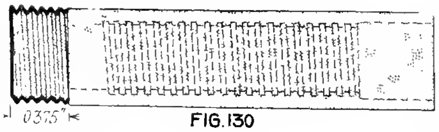


FIG. 130

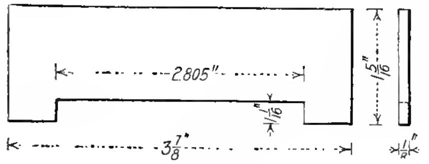


FIG. 133

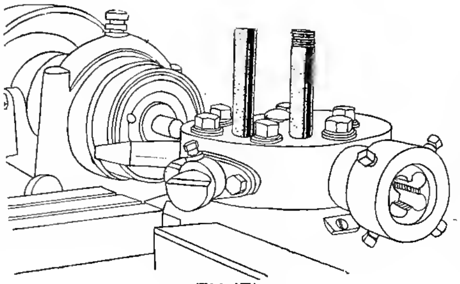
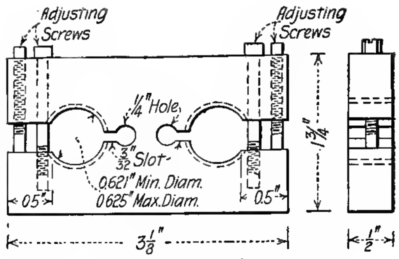


FIG. 131
OPERATION 2



18 Threads per Inch, Left Hand, U.S. Standard
FIG. 132

OPERATION 2. FACING END AND THREADING

Transformation—Fig. 130. Machine Used—Turret lathe, Fig. 131. Number of Operators per Machine—One. Work-Holding Devices—Collet chuck. Cutting Tools—Facing tool; die to cut 0.625 (+0.000, —0.004) diameter, 18 left-hand U. S. Standard thread. Cut Data—Speed, 850 r.p.m. Coolant—Lard oil. Gages—Maximum and minimum thread gage, Fig. 132; length gage, Fig. 133. Production—1200 per 8-hr. day.

OPERATION 1. PUNCHING INNER DISK

Transformation—Fig. 134. Machine Used—Small punch press. Number of Operators per Machine—One. Punches and Punch Holders—Fig. 135. Dies and Die Holders—Fig. 136. Lubricant—Mineral oil. Production—About 75,000 per 8 hr. Note—Press flywheel runs 70 r.p.m.

OPERATION 2. PUNCHING OUTER DISK

Transformation—Fig. 137. Machine Used—Small punch press. Number of Operators per Machine—One. Punches and Punch Holders—Fig. 138. Dies and Die Holders—Fig. 139. Lubricant—Mineral oil. Production—About 75.000 per 8 hr. Note—Press flywheel runs 70 r.p.m.

OPERATION 3. TURNING IGNITION TUBES

Transformation—Fig. 140. Machine Used—Brown & Sharpe automatic. Number of Machines per Operator—Three. Cutting Tools—Drill; countersink; formed tool; cutoff tool. Cut Data—Spindle runs 2400 r.p.m. Coolant—Zurn Cutting oil. Gages—Combination, Fig. 141. Production—3500 per 8 hr. Note—Made from ¼-in. diameter brass rod.

OPERATION 4. MILLING IGNITION TUBES

Transformation—Fig. 142. Machine Used—Hand miller. Number of Operators per Machine—One. Work-Holding Devices—Miller vise and formed jaws, Fig. 143. Cutting Tools—Milling cutter, 1¾ in. in diameter, 20 teeth. Cut Data—Cutter runs 600 r.p.m. Production—4000 per day.

OPERATION 5. ASSEMBLING IGNITION TUBE TO OUTER DISK

Transformation—Fig. 144. Number of Operators—One. Apparatus and Equipment Used—Bench riveter, Fig. 145. Production—1600 per 8 hr.

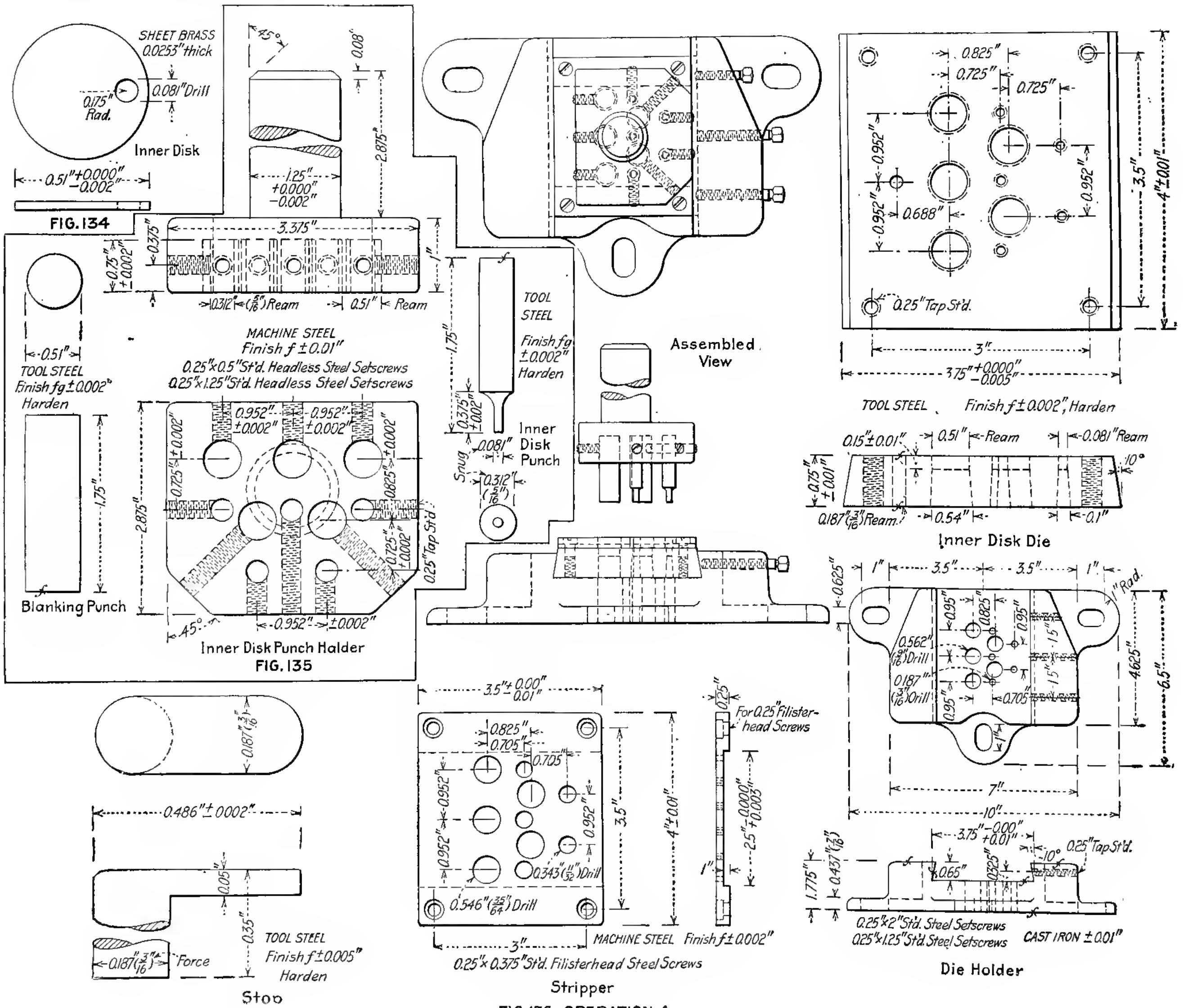


FIG. 136 OPERATION 1

The next in order is a thorough inspection of the entire case by a group of regular inspectors who also divide the shells according to weight, after which the inside back of the threads is sandblasted, as shown in Fig. 83. The shells are laid in a row on a wooden grating, open ends out, and the operator thrusts the sandblast nozzle into each in turn. This thoroughly cleans out the part of the cavity that has not been machined.

The hydraulic testing is done in the apparatus shown in Fig. 84 and in detail in Fig. 90. The test is an external one, a plug being screwed into the base to make it water-tight; then the shell is hoisted into the testing cylinder by means of a chain block hooked to a screw-eye in the base plug. The testing cylinder slides on ways, so as to be moved from loading to testing positions under the press ram. The moving of this testing cylinder is accomplished by the operation of a small hydraulic cylinder at the back of the press, the connecting-rod of which is coupled to the cylinder, as can be seen in Fig. 84. After the cylinder, full of water and with the shell inside, is in place under the press ram, the ram is lowered and pressure applied until it is equal to 350 tons, or about 20,000 lb. per sq.in. on the surface of the shell. This test shows whether there are any flaws, weak spots or blow-holes leading into the interior.

The first operation directly connected with the loading of the explosive charge is painting of the interior with acid-proof paint, the various loading operations being in the following order:

1. Painting interior by hand
1-A. Painting interior with a spray
2. Weighing
3-A. Filling with trinitrotoluol
3-B. Compressing the trinitrotoluol
4. Reaming for fuse case
5. Cleaning threads and counterbore
6. Painting outside
7-A. Putting in fuse (without night tracer)
7-B. Pressing on base cover (with night tracer)
7-C. Screwing in night tracer

Painting of the interior may be done in either one of two ways: By hand, using the outfit shown in Fig. 92, or with a spray, using the apparatus shown in Fig. 85. The hand method is slower, but may be used where a spray is not available or when it is out of order. The operator fills the cavity to the threads with paint and pours it out,

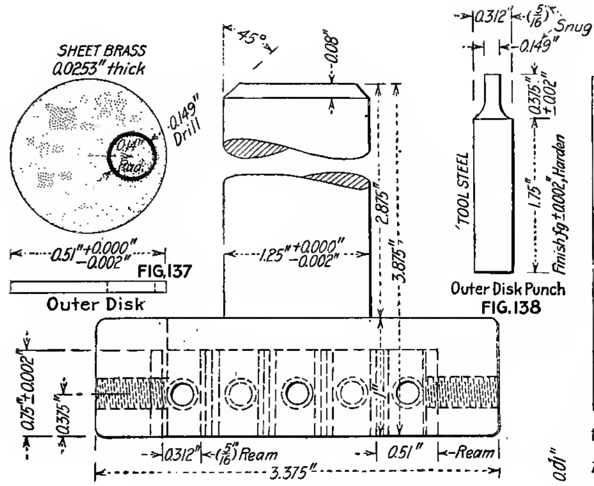
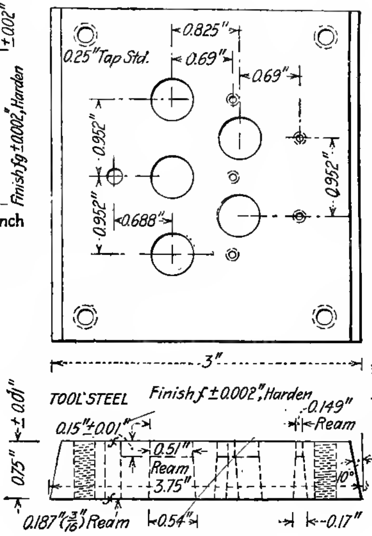


FIG. 137

Outer Disk Punch
FIG. 138



Outer Disk Die
FIG. 139

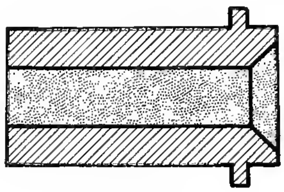
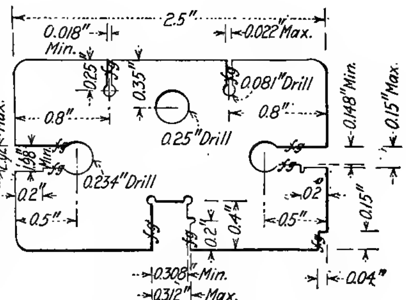
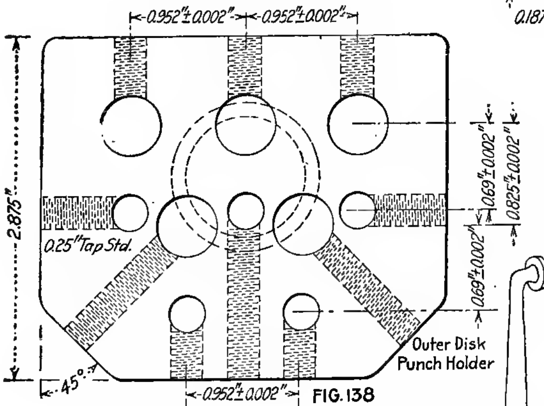


FIG. 140



MACHINE STEEL Finish f ±0.01", Case Harden
FIG. 141

MACHINE STEEL Finish f ±0.01"
0.25"×1.25" Std. Headless Steel Setscrews
0.25"×0.5" Std. Headless Steel Setscrews



Outer Disk Punch Holder
FIG. 138

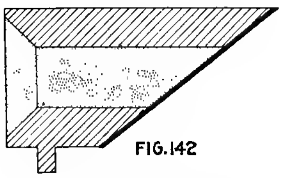


FIG. 142

FIG. 137, 138 & 139 OPERATION 2
" 140 & 141 OPERATION 3
" 142 & 143 " 4
" 144 & 145 " 5

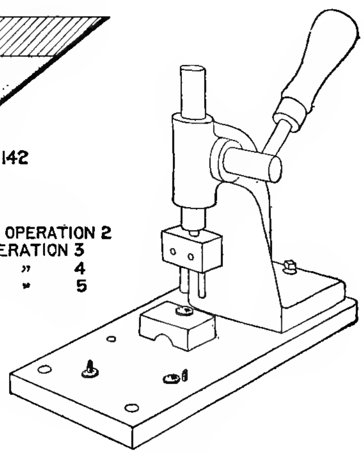


FIG. 145

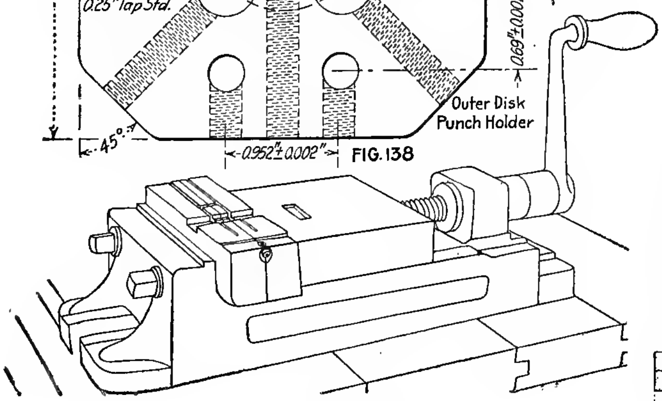


FIG. 143

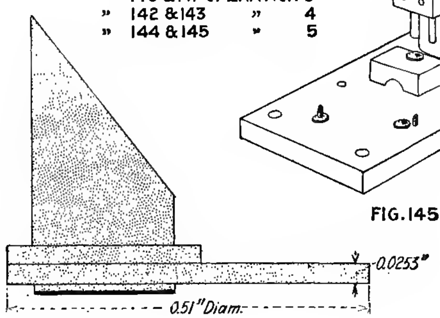


FIG. 144

OPERATION 1. LOADING ILLUMINATING POWDER

Transformation—Fig. 146. Number of Operators—Three. Description of Operation—Tracers are filled and mixture compressed in a bombproof with the same type of Riehle press used for trinitrotoluol loading; tubes are first filled with illuminant powder and placed 10 at a time in the fixture shown in Fig. 147 and given 40,000 lb. total pressure, equal to 4000 each; this is repeated three times. Apparatus and Equipment Used—Riehle hydraulic press; holding fixture and

OPERATION 5. TRIMMING END

Transformation—Fig. 153. Machine Used—Small turret lathe. Number of Operators per Machine—One. Work-Holding Devices—Collet chuck. Cutting Tools—Fig. 154. Cut Data—Spindle runs 350 r.p.m. Production—2000 per day. Note—Tracer is chucked and end of tube faced off until about 0.002 in. from outer disk; inside of mouth and disk is then coated heavily with nonacid paint, except opening in ignition tube: complete night tracer is shown in Fig. 155.

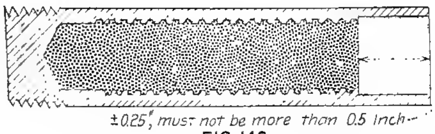


FIG. 146

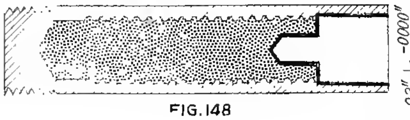


FIG. 148

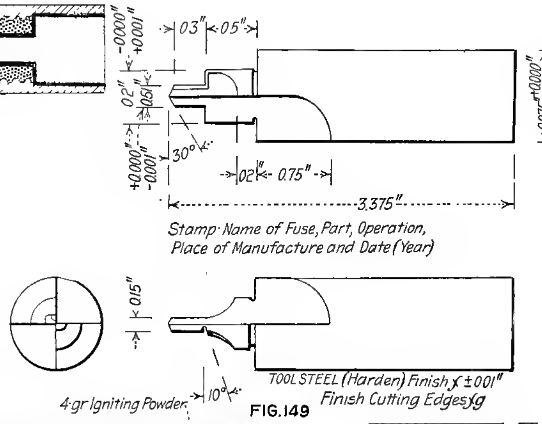


FIG. 149

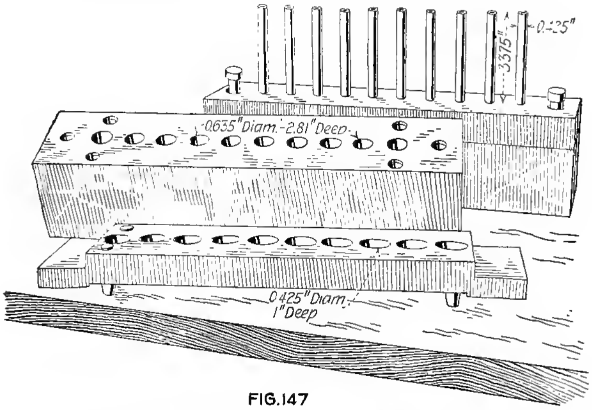


FIG. 147

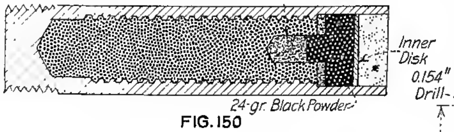
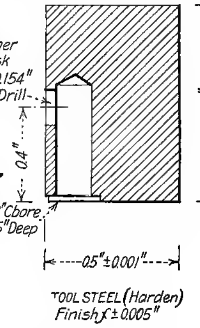


FIG. 150



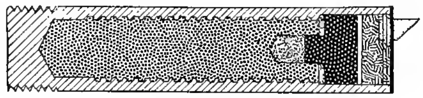


FIG. 153

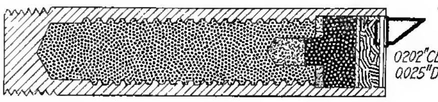


FIG. 151

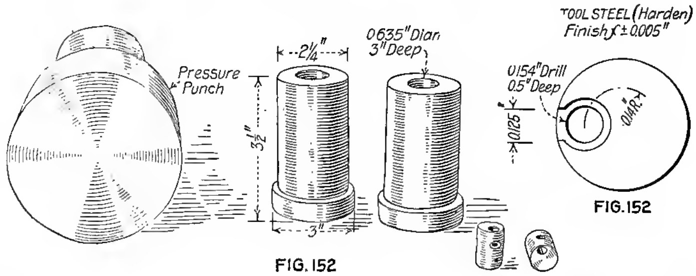


FIG. 152

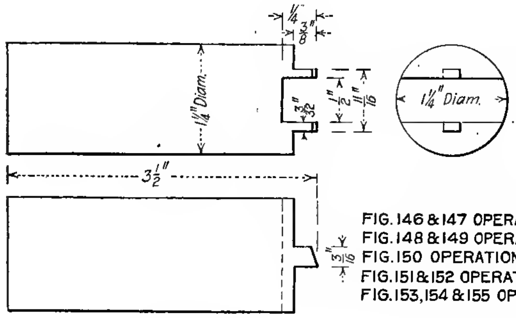


FIG. 154

FIG. 146 & 147 OPERATION 1
FIG. 148 & 149 OPERATION 2
FIG. 150 OPERATION 3
FIG. 151 & 152 OPERATION 4
FIG. 153, 154 & 155 OPERATION 5

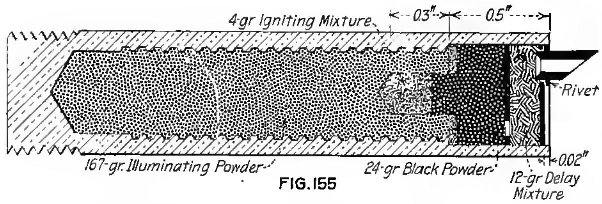


FIG. 155

pressing punches for 10 tubes; small-handled powder measures or dippers. Production—1000 per 8-hr. day.

OPERATION 2. COUNTERBORING

Transformation—Fig. 148. Machine Used—Small turret lathe. Number of Operators per Machine—One. Work-Holding Devices—Collet chuck. Cutting Tools—Counterbore, Fig. 149. Cut Data—Spindle runs 350 r.p.m. Production—2000 per 8-hr. day.

OPERATION 3. LOADING IGNITION MIXTURE

Transformation—Fig. 150. Number of Operators—Three. Description of Operation—4 gr. igniting mixture is poured into drilled and counterbored hole and shaken down; 24 gr. black powder is then poured on top of this and a brass inner disk placed on top of the powder; each tube is given 4000 lb. pressure, using the same fixture as for illuminant; in loading, two holders are used with one set of punches in the press, and they are employed alternately, as the illuminating and igniting powder are loaded in turn. Apparatus and Equipment Used—Same as for operation 1. Production—1000 per 8-hr. day.

OPERATION 4. LOADING RETARDING MIXTURE

Transformation—Fig. 151. Description of Operation—On top of the inner disk is poured 12 gr. delay mixture; the outer disk is put on, the holes in the two disks being placed on opposite sides; two tubes are compressed at once at 14,000 lb. total pressure, or 7000 each, using the holders and punches shown in Fig. 152. Apparatus and Equipment Used—Riehle hydraulic press in bombproof. Production—1800 per 8-hr. day

then passes the shell to another, who wipes the threads with waste. The spray method is far quicker and does not smear the threads so much, as the operator turns on the spray after the nozzle is inside the shell and turns it off before removal.

The weighing of the case is for the guidance of the fillers, the weight being chalked on each shell, as shown in Fig. 93. The fillers work in gangs of three, one filling, one carrying and refilling, and one operating the press. These operators shift positions or help on the different operations, as occasion demands in order to balance the work.

The high explosive, or trinitrotoluol, is a yellowish-white powder not dangerous in the ordinary sense, until compressed; but when compressed and fired by means of a detonator, it is one of the most powerful explosives known.

Compressing the trinitrotoluol is done with a hydraulic press placed in a concrete bombproof room, the operator watching the actual work by means of a mirror, as shown in Fig. 87. A shell in the holding fixture with the punch or rammer ready to descend is shown in Fig. 88. The rammer presses the explosive solidly into the shell and leaves a cavity for the insertion of the detonator. This cavity afterward has to be reamed out to size, which is done as shown in Fig. 97. The reamer is held in a chuck and passes over two jaws of a steadyrest, which not only steadies the reamer, but acts as a stop for the depth of the cut. Fig. 105 shows a stop collar on the reamer, but in the actual shop practice this is no longer used. The operator places a shell on the guiding block and presses it forward onto the revolving reamer until the end of the shell contacts with the steadyrest jaws.

After being reamed out, the threads and counterbore have to be cleaned. This is done by placing the shell on the fixture shown in Fig. 98 and using the hook tool there shown to clean the threads as the operator rotates the shell by hand. The counterbore is scraped out with a scraper made from an old file. Following these operations the shell is painted from point to band, while held as shown in Fig. 99, the operator applying the paint with wide brushes.

The detonator fuse is next screwed in, with the shell held in a bench vise, Fig. 100. A detonator is shown at *A*. If the threads are a little tight, a tap *B* is run in. If the hole is not quite deep enough or has not clearance enough, it is made larger by pounding and rotating the reamer *C* in the hole. With everything clear, the fuse is screwed home with the spanner *D* and locked to the notches in the shell with a punch and hammer. In case no night tracer is to be used on the shell, lead plugs are pounded into the spanner holes, and a sheet-metal cover *E* is put over the end with the edges in the cover groove. A calking lead ring *F* is then pounded into the groove as indicated in Fig. 109.

Where a night tracer is used, the fuse is put in in the same way, the lead slugs are pounded in, the special cover put on and a lead ring put in place. This ring, however, is not pounded in as previously described, but is pressed in as shown in Fig. 101, the process being graphically shown in Figs. 112-A and 112-B. Screwing in of the night tracer consists in placing the tracer in a vise and screwing the shell onto it by hand.

Making the Band

Operations on making the copper band are as follows:

1. Cut from tubing
2. Anneal
3. Pickle
4. Wash
5. Planish

The list of operations is almost self-explanatory; the details, however, are given under the proper headings. The last operation, planishing, is really a sizing for width, as the band is pressed between two flat dies, as shown in Fig. 102.

Making Night Tracer

1. Drilling, counterboring, tapping
2. Facing end and threading

Night tracers are made from brass rod in automatic screw machines; the order of procedure is as given above and is the usual standard screw-machine practice in every way.

Facing and threading of the closed end is done in a hand screw machine.

Making Night-Tracer Disks

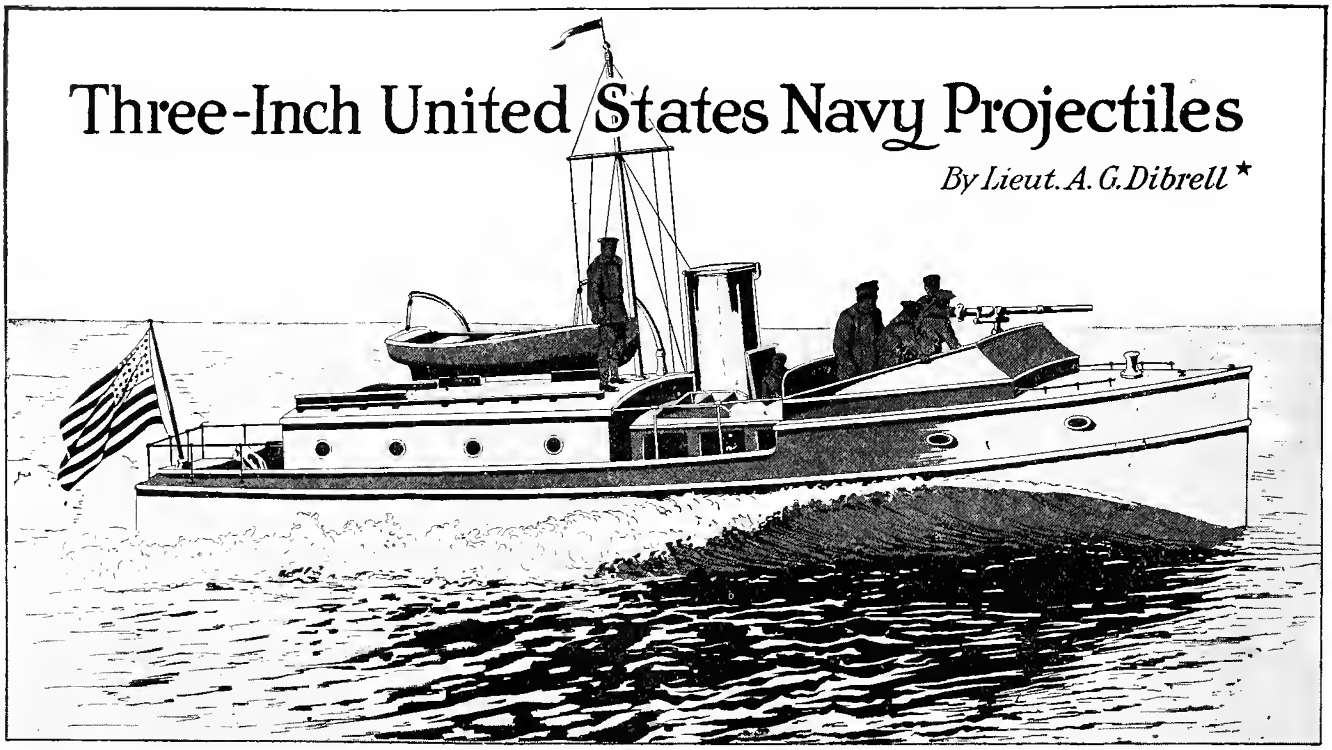
1. Punching inner disk
2. Punching outer disk
3. Turning ignition tubes
4. Milling ignition tubes
5. Assembling ignition tube to outer disk

The making of the disks is a punch-press job, as shown by the punches and dies, Figs. 135, 136, 138 and 139. The ignition tubes are made on automatic screw machines from brass rod and are milled off at a sharp angle on the outer end in a hand miller. The assembling of the ignition tube to the outer disk is done by hand, and then the tube is riveted fast in the disk in the bench riveter, Fig. 145.

Loading Night Tracer

1. Loading illuminating powder
2. Counterboring
3. Loading ignition mixture
4. Loading retarding mixture
5. Trimming end

The loading of the night tracer with the illuminating powder is done in a hydraulic press, using the holders and punches shown in Fig. 147. Several fillings and pressings are needed to complete the work. After the illuminating powder has been pressed in, it is machined out at the open end of the tracer in a small turret lathe, using the combination drill and counterbore, Fig. 149. The object of drilling into the illuminating powder is to give the ignition mixture a better chance of surely doing its work. The ignition mixture is next put in and the inner disk pressed in. On top of this a slow-burning powder is placed, and then the outer disk is pressed in. Finally, the end of the tracer is faced off with the tool shown in Fig. 154. The tracer is now ready to be screwed into the base of the shell. It may be noted that the thread on the base of the tracer is left-hand, so that there is no tendency to unscrew as the shell is fired from the gun.



Three-Inch United States Navy Projectiles

By Lieut. A. G. Dibrell *

SYNOPSIS—Shells of the size described here are required in large numbers for use in guns placed on destroyers or on boats of the type known as submarine chasers. These shells differ considerably from the 3-in. ones used in field guns or coast artillery, which have been previously described. The various machine operations are given with considerable detail.

The manufacture of munitions in navy yards, an experimental enterprise, inaugurated last year, has proved signally successful at Puget Sound. As a general proposition in peace times, the Government unquestionably is wise in giving such contracts to private individuals, thereby releasing its own plants for the more important repair work on ships. But the Government should nevertheless be able to perform any class of work necessary for the proper supply of the fleet in all its essentials and have definite information at hand for the use of individuals, should an emergency arise. In the machining of projectiles there is a great amount of preparatory work necessary—special-tool manufacture, gage manufacture and the equipping of machines—before the projectiles can be properly and economically machined. Evidence of this has been obtained in every munition plant visited. Hundreds of rejected shells were seen, most of which were made during the early stages of the shops' contracts. This was owing to the fact that the manufacturers had only drawings and specifications to guide them in the selection of necessary machines and equipment. The Government should furnish the American manufacturers with concrete actual working examples of all the minute details necessary for the proper and efficient manufacture of munitions.

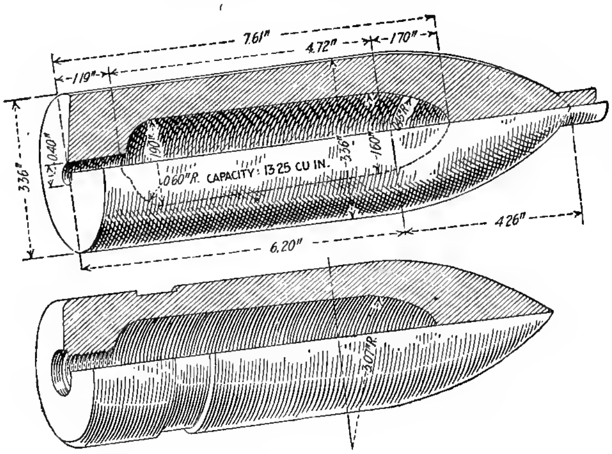


FIG. 1. DETAILS OF UNITED STATES NAVY THREE-INCH COMMON PROJECTILE

Owing to the great number of 3-in. shells that will probably be required to supply the submarine chasers and patrol boats now building, a description of the method adopted at Puget Sound is here given. The machines used are common to all shops, and it is hoped that this description will enable private individuals to equip their plants and be ready to start the work of machining as soon as forgings are received. Fig. 1 gives the dimensions of the 3-in. forgings furnished the navy yard by the American Car and Foundry Company. A radial drill is equipped for the first operation for the 3-in. shells. The chuck shown in Fig. 2 is a universal three-jaw lathe chuck. In the base of the chuck is a center point. The female center shown in the nib on the point of the rough forgings fits over this male point. The jaws of the chuck are then set up to hold the forging, while the small hole in the base is drilled out to $\frac{13}{32}$ in. in diameter. The center in the nib is concentric with the cavity of the forging, and the method of chucking and drilling the fuse hole in the base of the shell brings this hole also concentric with the cavity. The

*United States Navy, Submarine Division.

jaws of the chuck grip the shell about $2\frac{1}{2}$ in. from the base. The surface of the forgings is somewhat distorted by the dies in closing in the base, and the chuck must grip below this part of the forging. The swinging arm carrying a hardened bushing is closed to engage a permanent stop and fastened in place by a wing nut, as shown.

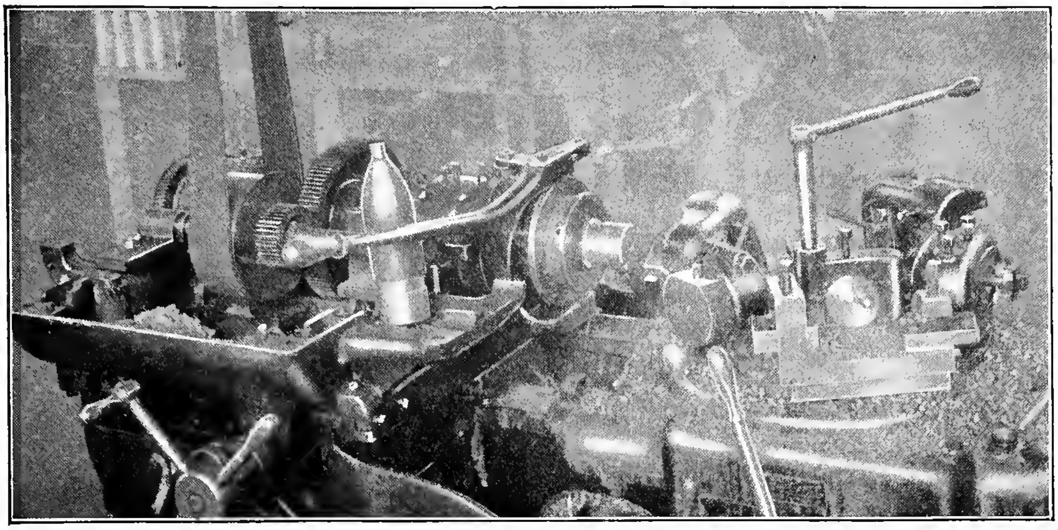


FIG. 5. TURNING BASE AND BAND SCORE

A $\frac{19}{32}$-in. twist drill running at 280 r.p.m. and with a feed of 0.008 in. is used to enlarge the hole. This permits the gage rods, shown at *A* and *C*, Fig. 3, in operation 2 to enter, and also removes rough stock for chasing the threads for the fuse. The lubricant is soap-water compound, which has proved very satisfactory for this work.

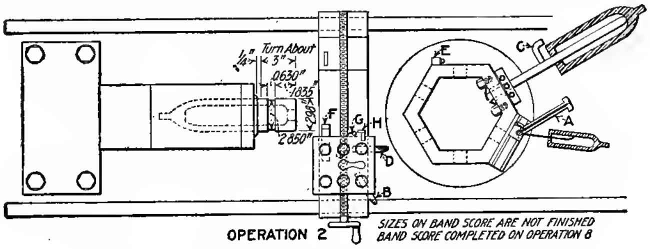


FIG. 3. ARRANGEMENT FOR OPERATION 2

Two machines are equipped for performing the second operation, as this operation requires the greatest amount of time to complete. A 16 x 20 x $1\frac{1}{2}$-in. Warner & Swasey belt-driven turret lathe and an 18 x 24 x 3-in. Jones & Lamson belt-driven turret lathe are used. Fig. 3 shows the Warner & Swasey lathe fitted for performing the operations. The forging is held in a collet chuck of six segments, separated by small springs, and each segment is knurled to give a better grip. The forging is first tested for eccentricity by means of the indicator *A*. The finger travels back and forth on the walls of the cavity and moves the pointer along the graduations shown. If the movement of the pointer exceeds the limits of the graduations, the forging will not clean up and is marked and set aside. The base of the shell is next faced off by the tool *B* on the turret head attached to the crossfeed to suit the gage *C* on the lathe turret. This establishes the dimension 7.42 in. from the nose of the cavity to the face of the base. About 3 in. of the base is next turned to a diameter of 2.995 in. by the tool *D*, finished by the tool *E* to 2.980 in. and the band score cut to a diameter of 2.850 in. and 0.630 in. wide by the tool *F*. The tool *G* rounds the base to the fillet shown on the drawing. The stop *H* is set for the tools *D*, *F* and *G*.

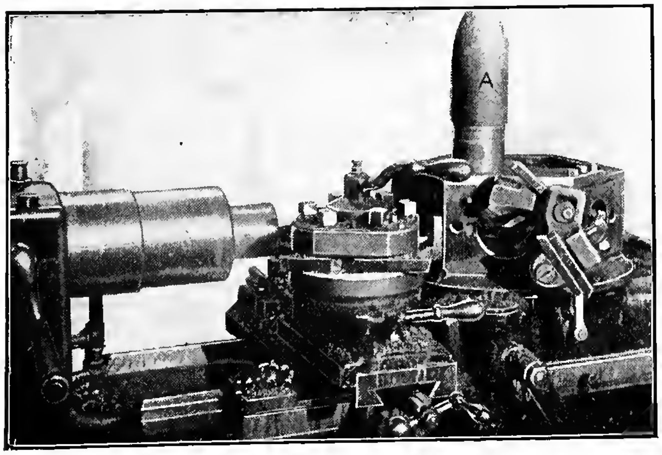


FIG. 4. TURNING BASE AND BAND SCORE

This machine is shown in Fig. 4; the view of the shell *A* on the lathe turret and *B*, Fig. 11, show the machining done. The turret head attached to the cross-slide is an ordinary square turret head holding tools at the corners. The lubricant used in this operation is a compound of soap and water. The cutting tools are all of tungsten tool steel. The Jones & Lamson turret lathe, Fig. 5, works continuously on operation 2, the tool layout being shown in Fig. 6. All selective gear is removed from the spindle drive, and a single back-gear shaft is installed. The forging is gripped in a draw-in collet chuck, operated by hand lever, the female center hole in the nib of the forging fitting over a male center point at the rear of the chuck. The depth of the chuck allows about $3\frac{1}{2}$ in. of the forging at the base clear for machining. The diameter at the base is rough turned by the tool *A* at 45 ft. per min. speed, 0.01-in. feed and $\frac{5}{32}$-in. cut. (Where fins have been left by the closing-in die at the base, the depth of cut is more than $\frac{5}{32}$ in.) The turret is indexed one position, a straight gage rod is inserted in the base hole,

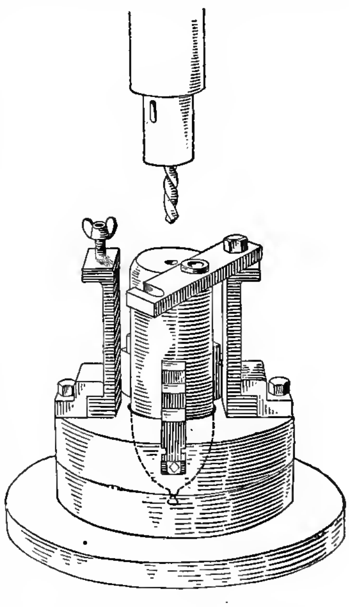


FIG. 2. DRILLING CENTERS

and the forging is faced off at the base by the tool *B* the correct length, which in this case is 7.042 in. from the extreme point of the cavity in the shell.

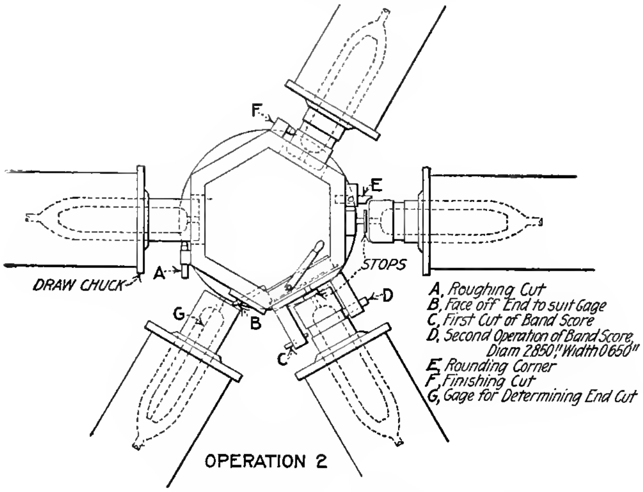


FIG. 6. TOOL LAYOUT FOR OPERATION 2

The work runs at the same speed and feed with $\frac{5}{16}$-in. cut. The turret is again indexed, and the band score is roughed out with the narrow tool *C* and finished with

center supported through the turret hole, suitably arranged for quick disengagement when the work is unchucked. The roughing cut is taken over the body forward of the band score to the bourrelet, as shown in Fig. 8 and at *C*, Fig. 11. Two tools are used in the special carriage mentioned above to shorten the distance of tool travel. A speed of 55 ft. per min., $\frac{1}{64}$-in. feed and

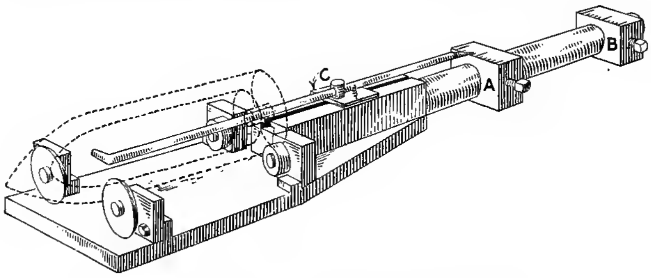
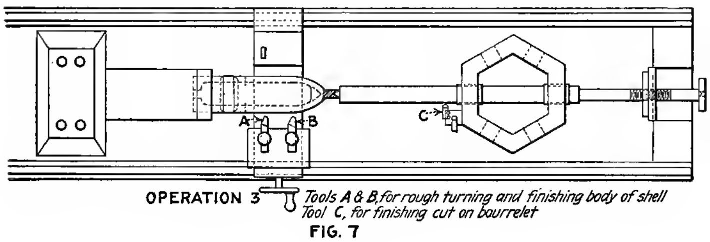
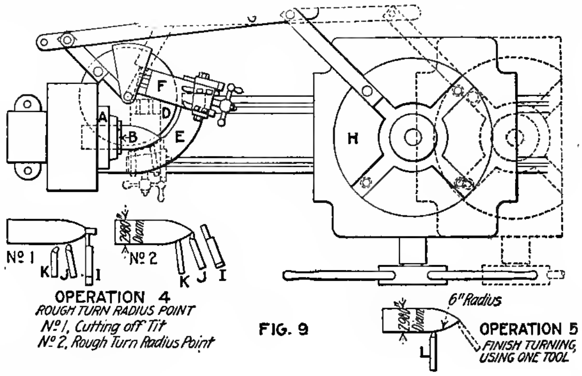


FIG. 13. TESTING FOR ECCENTRICITY

$\frac{5}{32}$-in. cut are adopted for this operation. Forgings are run through in lots of 100 on the roughing cut and then run through for a finish cut. In this manner, time is saved, owing to the rapidity with which forgings can be chucked and unchucked and to the fact that the roughing cut does not require accuracy. For the finishing





FIGS. 7 AND 9. TURNING OPERATIONS
Fig. 7—Details for operation 3. Fig. 9—Turning operations on the point

the $\frac{5}{8}$-in. wide-nose tool *D*. The feed and cut are regulated by hand through a cutting-off lever. The turret is again indexed, and the tool *E* rounds off the corner of the base with the machine running at the same speed. The finish cut is taken between the groove and the base of the forging on the next index of the turret, the tool *F* being used. The speed of the work is 120 ft. per min., $\frac{1}{60}$-in. feed, 0.007-in. cut. The lubricant is soap-water compound. Fig. 7 shows the Warner & Swasey lathe fitted for operation 3. The lathe has a special turning carriage fitted to the ways, being pushed forward by a regular turret saddle, which furnishes the power feed. The forging is gripped by a draw-in chuck at the base end, which has been finished in operation 2. The female center in the nib of the forging runs upon the male

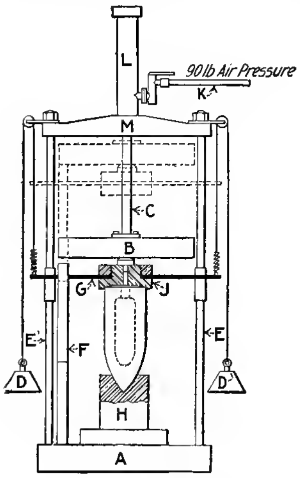


FIG. 14. MARKING THE BASE

cut the work is rechucked as before; the tools *A* and *B*, Fig. 7, finish cut the body, and the tool *C* on the turret finishes the bourrelet to micrometer sizez. On the finish operation, 175-ft. speed, $\frac{1}{64}$-in. feed and 0.007-in. cut are used. Soap and water compound is employed in both operations.

Operation 4 consists in roughing the radius point, and operation 5 in finishing the point. Both these operations

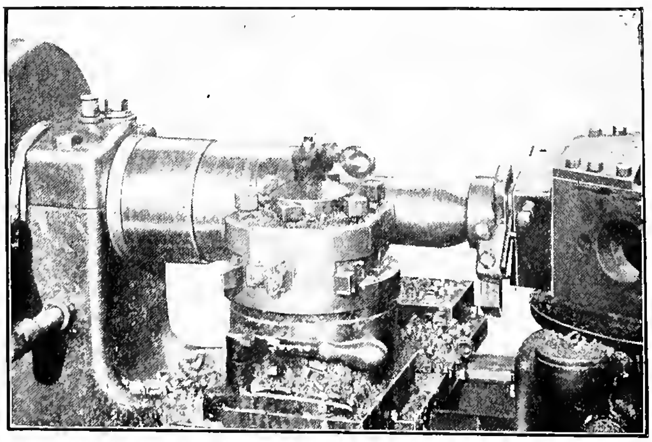


FIG. 8. TURNING FORWARD OF BAND SCORE

are performed in the same machine, a 2 x 24 x 13-in. Jones & Lamson turret lathe, from which the back gearing has been removed and a wide-belt drive connected directly to the spindle. The diameter of the spindle being smaller than the diameter of the projectile, a special outboard bearing *A*, Fig. 9, is fitted to take the overhang from the forward journal. The shell is gripped just back of the bourrelet in a collet chuck *B*. The cross-slide from an engine-lathe carriage is bolted to the swivel base *D* of a planer vise, and this rig is bolted securely to the ways of the turret lathe in correct position for turning the radius point on the fixed center, as shown in Fig. 10. The crescent-shaped casting, which is shown at *E*, is bolted to ways to furnish a bearing surface beneath the tool slide *F*. It has a brass wearing shoe of greater radius than the cutting tool, to prevent springing; a link *G* connects the base to the turret saddle *H*, and the circular movement for radius turning is thus derived from the straight-line travel of the saddle. The ordinary feed mechanism of the turret lathe gives automatic power feed. The tool-holding block carries three tools, as shown. The swivel is moved into position so that the cross-slide engages a stop screw fastened on the face of the outboard-spindle bearing, and the cutting-off tool *I* is then in position to cut off the nib, the feed being made by hand screw.

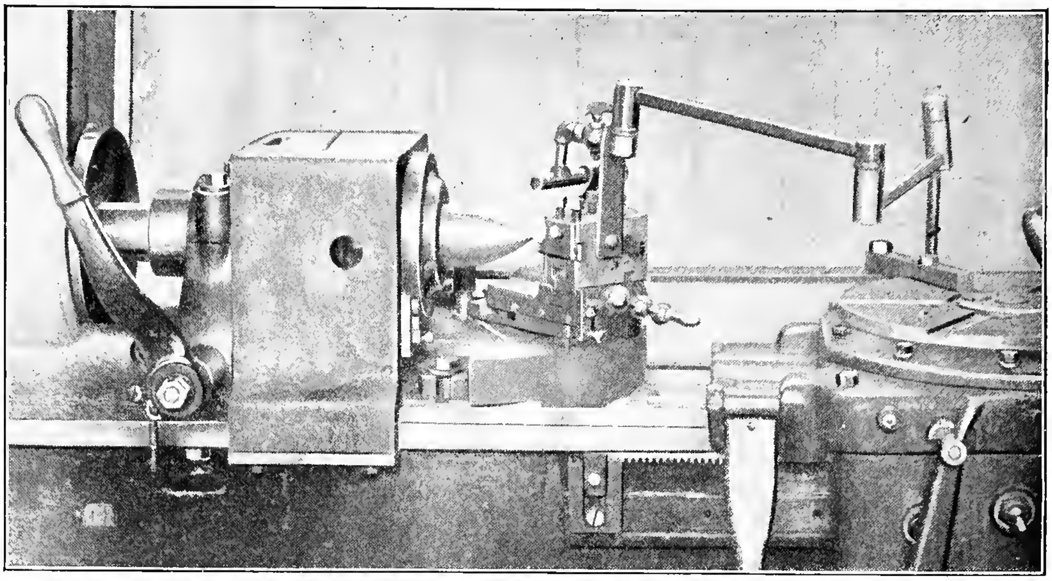


FIG. 10. TURNING RADIUS POINT

distance from the center of the swivel *D;* both tools, therefore, cut in the same plane. By using the two tools the entire surface of the radius point is machined when the tool block moves one-half the distance from the point to the bourrelet. Owing to the great excess of metal on this part of the forgings, it has been found necessary to take two roughing cuts. Furthermore, the radius point is not forged concentric with the straight body. The machine runs at a speed of 200 r.p.m., and the first roughing cut is approximately $\frac{1}{4}$ in. deep and $\frac{1}{120}$-in. feed. For the second roughing cut, the machine runs at the same speed, which gives about 150 ft. per min. at the largest diameter, with a cut $\frac{5}{32}$ in. deep. Lots of about 100 are rough turned, and the machine is shifted for finish-turning operation 5.

For the finishing cut the forging is chucked as before; the feed is reversed so that the finishing tool *L* will

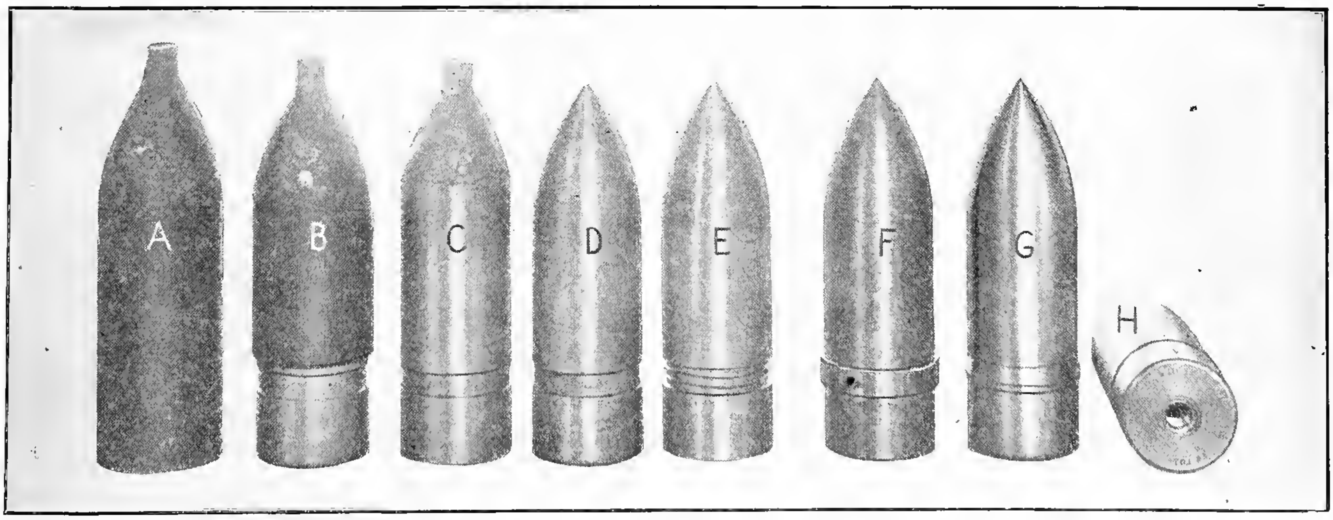


FIG. 11. SHELLS IN DIFFERENT STAGES OF MACHINING

The turret saddle *H* is moved by hand until the tool *J* is at the nose of the forging, the depth of the cut being adjusted by means of the regular crossfeed screw. The tools *K* and *J* are permanently set at the same travel from the bourrelet to the point of the shell. For finishing, a speed of 240 r.p.m. is used, about 180 ft. per min. at the largest diameter, 0.01-in. feed and 0.015-in. cut. The lubricant for both operations is soap-water compound. A jet for each tool is so regulated that it may be utilized on one or all tools, as desired. The shell at *D,* Fig. 11, shows the condition after leaving this machine.

Operation 6 consists of weighing and gaging to this point (outside of forging finished) and again after the copper band has been finished. The leadingman and the inspector perform this operation. Fig. 12 shows the scale and various gages. Fig. 13 shows the gage for testing the 3-in. projectiles for eccentricity. The shell is laid on the rollers; the finger of the gage is inserted through the fuse hole, as shown, and is held against the walls of the cavity by the small spring on the block *C,* which slides in a slot milled in the casting. The pointer indicates on the blocks *A* and *B* the amount of eccentricity, the graduations being in thousandths of an inch. The shell is revolved on the rollers by hand. The following tests are made here: Gage bourrelet for size; gage body for size; test for eccentricity; gage length; weigh in rough and finished; gage copper band· test capacity of cavity; gage fuse-hole threads.

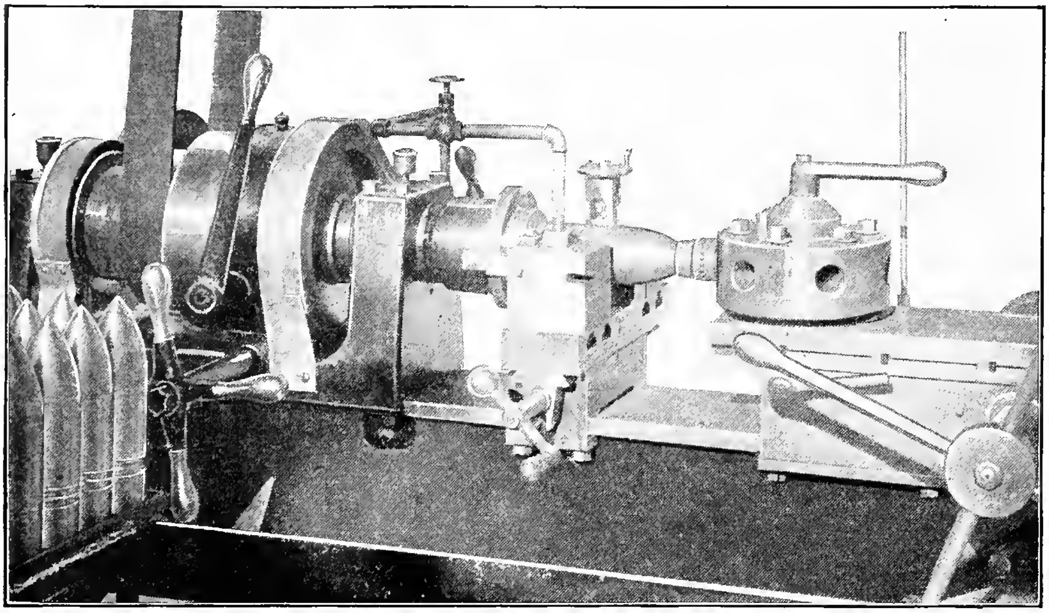


FIG. 15. TURNING SINUSOIDAL WAVES

Fig. 14 shows the device for marking the base, operation 7. It consists of the cast-iron base *A* supporting the two uprights *E,* across the top of which is the yoke *M.* On top of *M* is an air cylinder *L* operated by the lever *K.* The marking die *J* is supported by the plate *G.* The counterweights *D* are attached to the plate *G,* which slides on the two uprights for lifting the plate and die after marking. The conical chuck *H* holds the shell, base up, for marking. The weight being up at the position shown by the dotted lines, the action is as follows: The die is placed over the base of the upturned shell and secured. The air exhaust valve in the cylinder is opened, permitting the weight *B* to fall by gravity from a height of 10 in. There is a small rebound, but this does not affect the marking. The air pressure is turned on, lifting the weight. The die is removed, the counterweights lifting the die and plate. The shell is removed—another one put in the chuck.

Operation 8 is performed in an old-style wire-feed belt-driven Bardons & Oliver $1\frac{1}{2}$ x 14 x 16-in. screw machine, Fig. 15. In order to obtain sufficient diameter to grip the base of the projectile, a special draw-in chuck was made for the spindle. A three-throw cam of tempered steel is secured to the outside of the chuck body, to give the tool the movement necessary for cutting the sinusoidal ribs in the copper-band score. Fig. 16 shows the tool set up for this operation. A comb-shaped tool is held in a block on the cross-slide, as shown at *A.* When the slide is moved forward, this tool shaves the body of the band score to the correct width and diameter, leaving

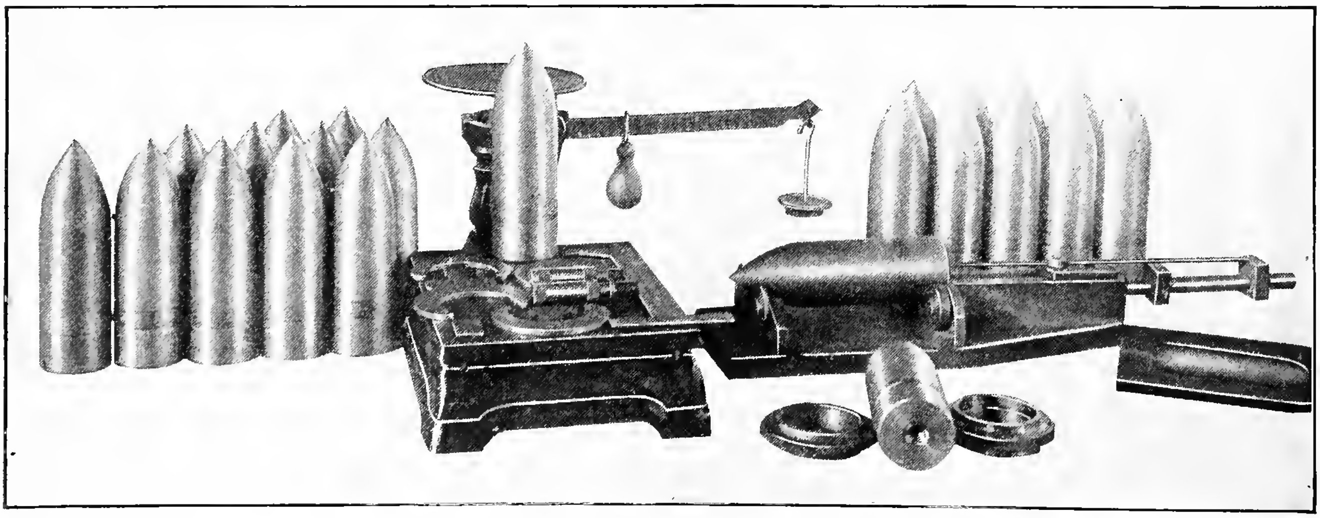
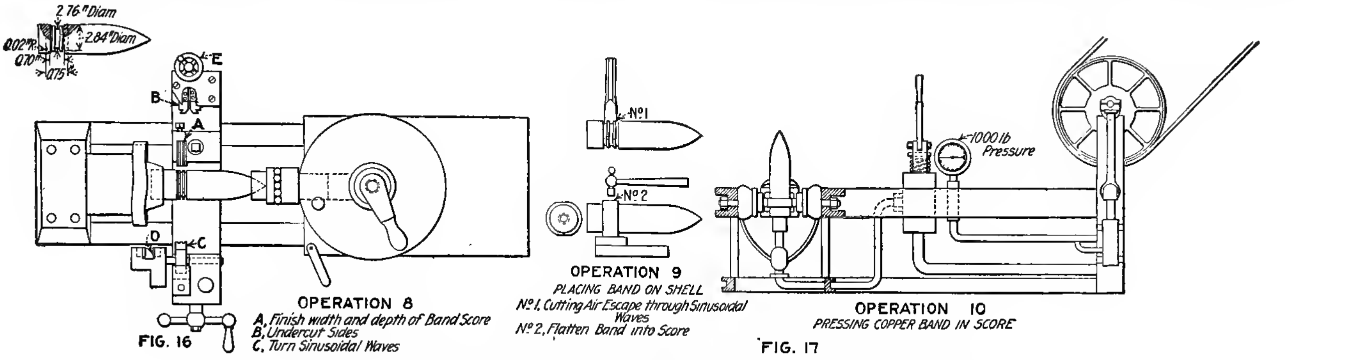


FIG. 12. INSPECTING, WEIGHING AND TESTING

ribs sufficiently wide to permit the tool *C* to finish the sinusoidal waves. The tool *A* travels underneath the forging until the slide engages an adjustable stop, at which time the undercutting tool *B* at the rear of the slide is in position to function. The operator turns the small handwheel *E* operating a wedge that forces the undercutting tools to the sides of the groove, the width and depth of undercut being regulated by suitable adjustable stop screws. The operator reverses the direction of the handwheel, and the undercutting tools collapse, permitting their withdrawal from the cutting position.



FIGS. 16 AND 17. OPERATIONS FOR BANDING
Fig. 16—Set-up for cutting the sinusoidal ribs. Fig. 17—The banding operation

The cross-slide is next fed in by means of the regular feed screw until the yoke and the rollers *D* connected to the wave-cutting tool *C* in the front tool-holding block engage the cam on the chuck previously described. The cam produces lateral motion in the tool *C*, which forms the sinusoidal waves. The cross-slide is fed in until the stop is reached, which is set for the correct diameter of the top and bottom of the waves. The distance of the band score from the base of the forging is permanently maintained by a shoulder in the chuck, which engages the base end of the forging. The nose of the forging is supported in a ball-bearing female center held in the turret hole. The tools are made of tungsten tool steel and may be ground upon their faces without changing their shape. Soap-water lubricant is employed. A speed of 35 ft. per min. is used, all feeds being made by hand.

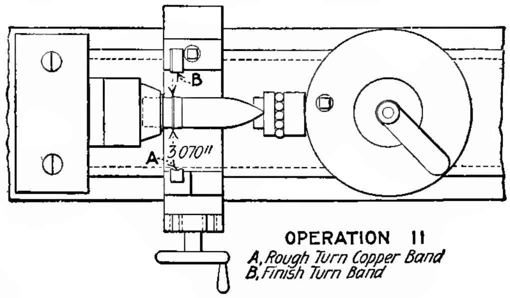


FIG. 18. TURNING THE COPPER BAND

Operation 9 consists in cutting air vents in the sinusoidal ribs and fitting the copper band ready for the banding press. Fig. 17 shows the banding press and the method of performing this operation. In order to shift quickly from the 6-in. banding to the 3-in., special 3-in.

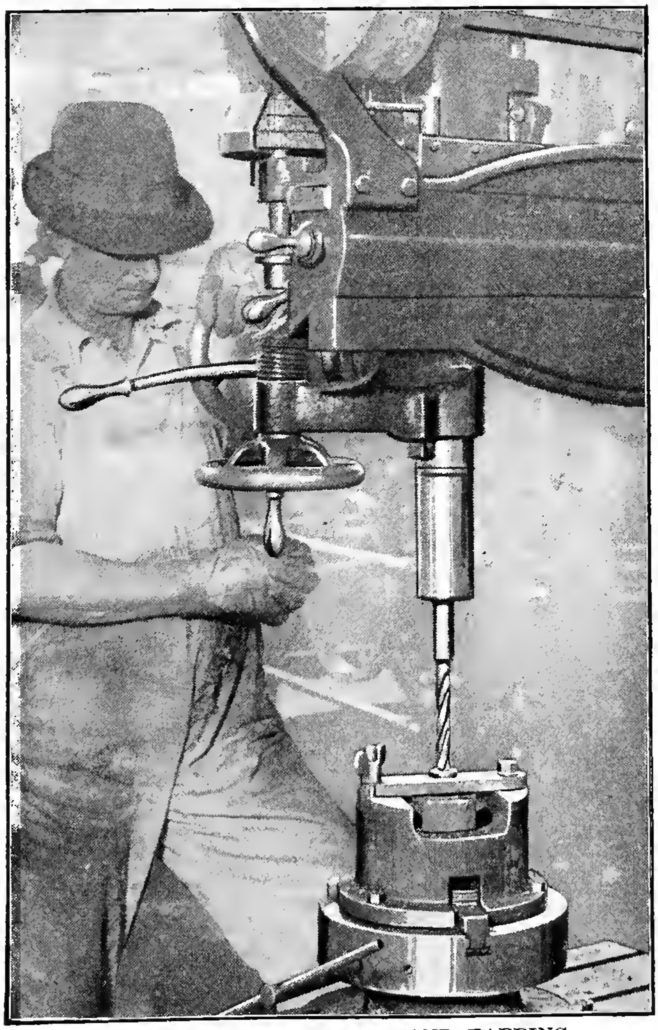


FIG. 20. COUNTERBORING AND TAPPING

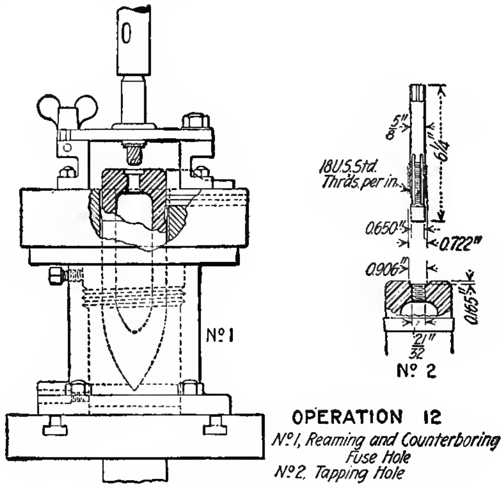


FIG. 21. MACHINING THE FUSE HOLE

dies were made to bolt to the regular 6-in. dies furnished by the manufacturers of the banding press. A gage pressure of 1000 lb. is used, which gives about 40 tons'

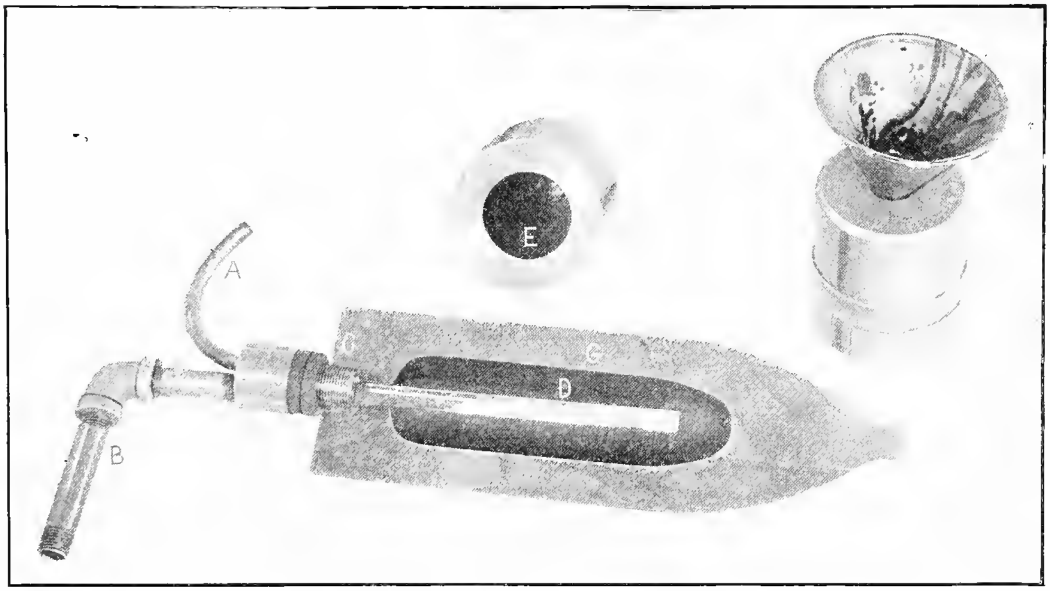


FIG. 23. LACQUERING INSIDE OF SHELL

pressure on the band. Two squeezes of the press are required.

Operation 11 consists in rough turning and finishing the copper band. This is performed in an old-style belt-driven 3 x 16 x 20-in. Pratt & Whitney wire-feed screw machine. A special chuck and a ball-bearing female center, similar to the ones described for the Bardons & Oliver machine, operation 8, were manufactured for this machine. A rigid tool block, holding the formed cutter

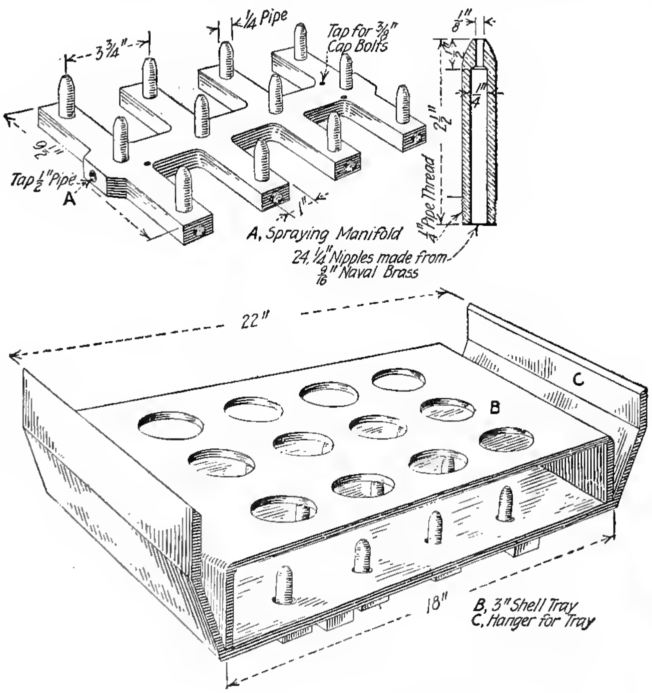


FIG. 22. DETAILS OF SHELL-HOLDING TRAY

A, Fig. 18, is fastened to the front end of the cross-slide. The line of travel of the tool *A* is in line with the center of the forging, the final depth of cut being regulated by a permanent stop to the slide. The roughing out is made with this tool, which cuts full width and the exact contour of the band. A similar tool block is bolted to the tool slide at the rear and holds the tool *B*. The line of cut of this tool is tangent to the perimeter of the band and is set at the correct height for shaving the diameter to exact size. The cutting tools are made of tungsten special steel, are interchangeable and may be ground on their faces without changing their shapes. The speed is 40 ft. per min. The feed is regulated by hand. The lubricant is soap-water compound. Fig. 19 shows the machine in operation. The radial drill used for operation 1 is also equipped for performing operation 12. The shell is held in a three-jaw universal lathe chuck mounted in a cast-iron elevating stand that is bolted to the drilling-machine table, as shown in Fig. 20 and in detail in Fig. 21. The bottom of the stand has a female center hole in which the point of the shell rests. The jaws of the chuck grip the shell between the copper band and the base. A swing leaf that carries a hardened bushing is moved to a permanent stop and locked in place by a fly nut. A counterbore, the body of which fits the hardened bushing, is fed down to the work by means of the hand lever.

The pilot end reams the fuse hole to the correct tapping size, and the recess is counterbored to the correct diameter and depth for the flange on the fuse. The shank of the counterbore fits in the drill spindle and is easily removed. The speed for counterboring is 100 r.p.m. Soap and water compound lubricant is used. The counterbore tool is removed, and the tap and socket are inserted in the drill spindle. The swing leaf is moved to one side, and the pilot at the end of the tap is entered in the reamed fuse hole, thus assuring that the threads will be cut concentric with the base. The tap is run at 30 r.p.m., with pure lard oil as a cutting lubricant.

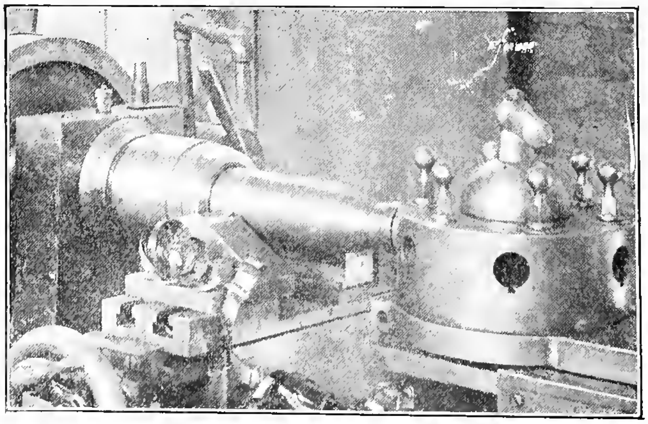


FIG. 19. TURNING BAND

The washing and lacquering are done in operation 13. The tanks, tables and benches made for the 6-in. projectiles are used for the 3-in. shell. Fig. 22 shows the tray made to hold twelve 3-in. shells, each shell fitting over a nozzle that thoroughly washes the inside of the shell. By means of the air-hoist cylinder the tray is suspended in the tank containing the washing solution; then it goes to the fresh water for rinsing, and afterward to the drain board. The cavity is dried by compressed air.

Lacquering the Cavity

When the cavity is thoroughly dry, the lacquering is done, as shown in Fig. 23. The funnel in the base of the cut shell has a long spout that extends below the fuse threads. A small amount of lacquer is poured into the cavity through the funnel, and the pipe rig, shown in longitudinal cross-section of the forging, is screwed into the fuse hole. When the plug is screwed home, the end of the pipe *D* is immersed in the lacquer previously poured in, just clear of the cavity point. The compressed-air pipe is connected to *B*, which throws the lacquer out against the inner walls of the shell, the excess escaping by the discharge pipe *A*. At *E* may be seen a shell that was cut to determine how well the surface was covered; no bare spots could be found.

The fuse hole is closed by waste or a fuse plug, and the projectile is painted on a turntable. The shells are then sent to the magazine for loading and stowing, ready for issue to the service as acquired.

United States Common Shrapnel and Common Steel Shells, 3.8, 4.7 and 6 In.*

The following specifications and operation lists for the different projectiles shown, taken together with those already published for the 3-in. sizes, will give manufacturers and shopmen something definite to work from in deciding on the capacity of their shops in the production of munitions of this character.

The 3.8-In. Common Shrapnel (30 Lb.)

Fig. 1 shows the dimensioned forging for the 3.8-in. common shrapnel; Fig. 2 is the dimensioned finished case, while Fig. 3 illustrates the complete projectile.

Operations on the Case (Forging)

OPERATION 1. CENTERING

Tools and Fixtures—No. 42 combination center drill; chuck and arbor.

OPERATION 2. TURN BODY

Tools and Fixtures—Special arbor; right-hand lathe turning tool and arbor press. Gages—Combination maximum and minimum snap for diameter of body; maximum and minimum ring rear of band; length from base to bourrelet.

OPERATION 3. FINISH EXTERIOR

Tools and Fixtures—Set of eight chuck pads; facing tool; circular form tool; circular form tool holder; knurling tool; knurling-tool holder. Gages—Combination minimum and maximum band seat; maximum and minimum width and depth of band seat; position of band seat and grooves; thickness of base and test piece; length over all.

OPERATION 4. FINISH INTERIOR, ROUGH-TURN BOURRELET, ROUGH-TURN OGIVE

Tools—Set of chuck pads; diaphragm-seat finishing cutter; diaphragm-seat cutter bar; tap; ogive cutter; right-hand rough-turning tool. Gages—Maximum and minimum diameter of diaphragm seat; depth of diaphragm seat; maximum and minimum thread plug gage; maximum and minimum diameter of powder chamber; maximum and minimum root of thread.

OPERATION 5. ASSEMBLE HEADS

Tools—Special wrench.

OPERATION 6. FINISH-TURN HEAD AND BOURRELET

Tools—Right-hand turning tool; form; rear of cross-slide follower; special chuck; revolving center. Gages—maximum and minimum ring gage; diameter of bourrelet; ogive profile gage; diameter of nose thread plug.

OPERATION 7. DISASSEMBLE HEAD

Tools—Special wrench.

OPERATION 8. HYDRAULIC TEST

Special Fixtures—Test fixture.

OPERATION 9. ASSEMBLE BAND

Equipment Used—Set of banding dies; pair of tongs; gas furnace.

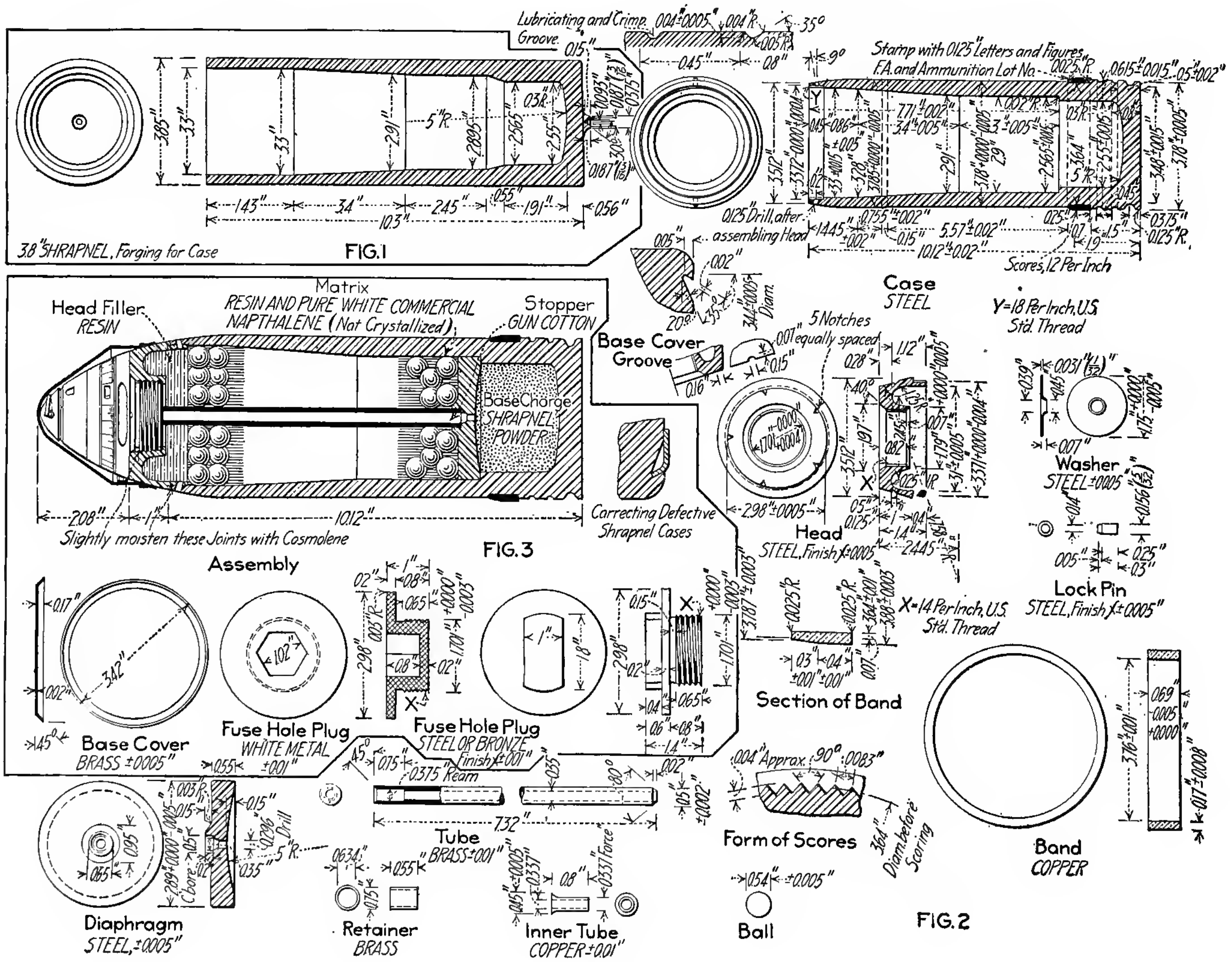
OPERATION 10. TURN BANDS

Tools—Special chuck; steadyrest; form; rear of cross-slide follower; facing tool; band-turning tool; special stop; tool-post holder rear of cross-slide. Gages—Maximum and minimum ring gage diameter of band; profile and position of band.

OPERATION 11. WASH IN HOT SODA

Equipment Used—Pair of tongs.

OPERATION 12. PAINT INSIDE



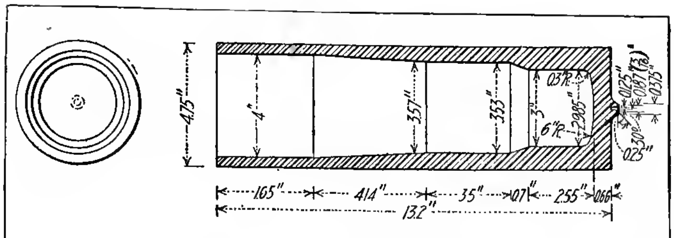


FIG. 4

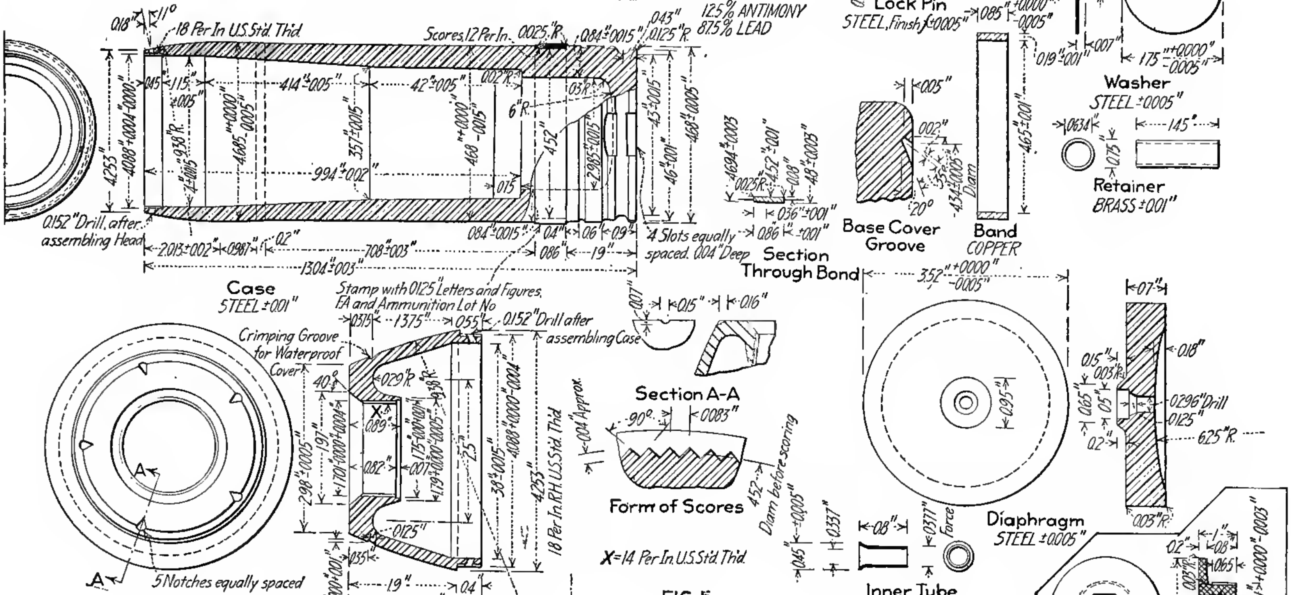


FIG. 5

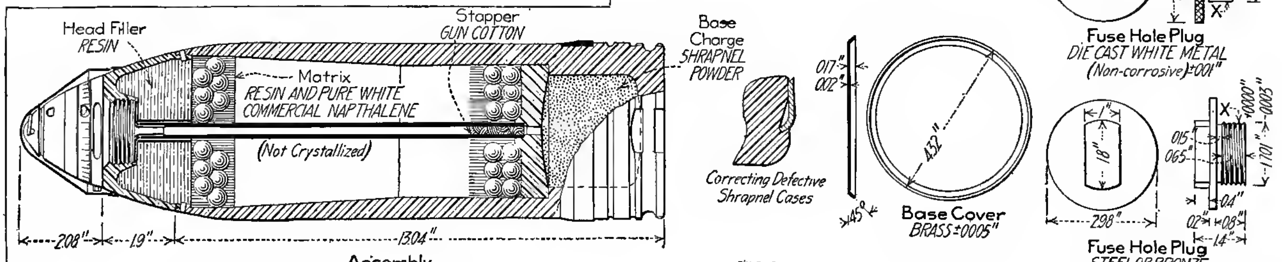


FIG. 6

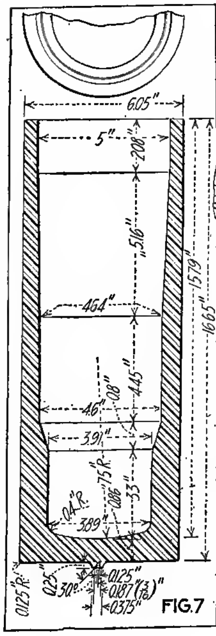


FIG. 7

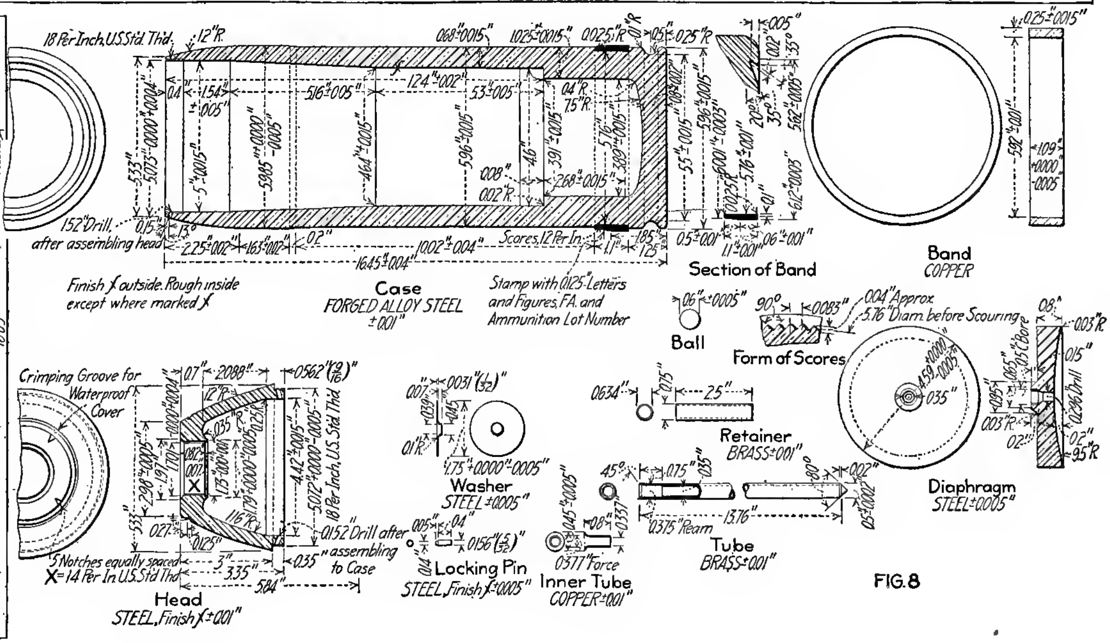


FIG. 8

Operations on the Head

After the head has been rough-machined, it is assembled to the case, as the fifth operation on the case. The head and bourrelet are then finish-turned.

OPERATION 1. MACHINE FROM BAR

Tools and Fixtures—Set of chuck pads and bushings; feed shell pads and bushings; stop; twist drill; drill holder; set rough grooving tools; set rough combination grooving tools; holder; set finish grooving tools; combination counterbore and reamer; collapsible tap and chasers; double-end flat forming tool; cutting-off tool and suitable holders. Gages—Length and diameter of thread; length from front to thread; inside diameter of crimping wall; maximum and minimum thread plug; depth of groove; length over all.

OPERATION 2. COUNTERSINKING

Tools—Chuck; beveling tool. Gages—Diameter and profile of fuse-seat bevel; minimum diameter of fuse seat and fuse-seat thread.

OPERATION 3. THREAD AND CRIMP IN STEEL WASHER

Tools—Chuck; crimping tool; circular thread cutter; leader and follower. Gages—Maximum and minimum thread ring.

Inner Tube

OPERATION 1. MACHINE

Tools—Stop; 60-deg. countersinks; belling tool; chamfering tool; cutoff tool. Gages—Combination length and diameter of bell.

Central Tube

OPERATION 1. MACHINE

Tools—Reamers for inner-tube seat; 90-deg. countersinks; cutoff tool; chamfered tool. Gages—Length; combination depth and diameter; inner-tube seat.

Washer

OPERATION 1. PUNCH

Tools—Punch and die.

Diaphragm

OPERATION 1. DRILL AND COUNTERBORE

Tools—Special chuck; twist drill; counterbore; countersink and holders. Gages—Maximum and minimum plug; diameter of counterbore; depth gage for counterbore; maximum and minimum ring; outside diameter.

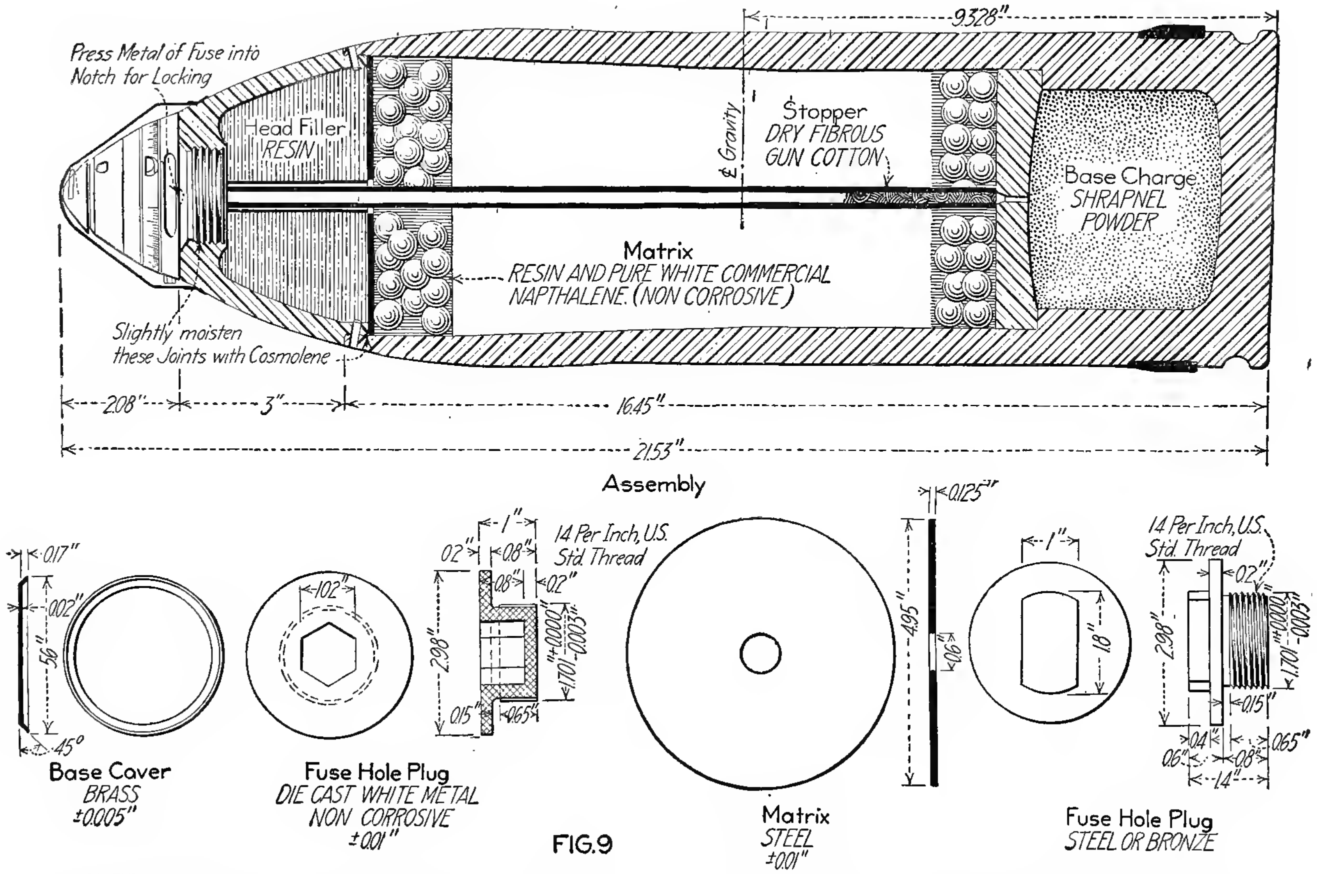


FIG. 9

OPERATION 4. MILL NOTCHES IN HEAD

Special Fixtures—Milling cutter and arbor.

OPERATION 5. GROOVE FOR WATERPROOF COVER

Tools—Screw chuck; special lathe tool. Gages—Waterproof-cover scratch gage; position of waterproof-cover groove.

OPERATION 6. PAINT INSIDE HEAD

OPERATION 7. PUT IN RETAINER AND FILL HEAD

OPERATION 8. CUT OUT SURPLUS RESIN

Tools—Special chuck and right-hand side-facing tool.

OPERATION 9. COAT THREADS WITH COSMOLINE

OPERATION 10. REASSEMBLE HEAD TO CASE

Tools—Special wrench.

OPERATION 10-A. INSERT INNER TUBE

Tools—Punch.

OPERATION 11. PIN HEAD TO CASE

Tools—Drill chuck; twist drill; fixture for holding case.

OPERATION 12. FINAL INSPECTION

Locking Pins (Bar Stock)

OPERATION 1. MACHINE

Tools—Stop; cutoff tool; form tool. Gages—Length.

Retainer

OPERATION 1. MACHINE

Tools—Stop; cutoff; chamfer tool. Gages—Length.

OPERATION 2. HEAT-TREATMENT, 1600 DEG. F.

OPERATION 2-A. PLACE IN COTTONSEED-OIL BATH

OPERATION 2-B. RUMBLE IN HOT SALT TO REMOVE SCALE

OPERATION 2-C. HOT SALTPETER BATH, 900 DEG. F.

OPERATION 3. REMOVE SCALE FROM COUNTERBORE

OPERATION 4. GRIND BASE

OPERATION 5. PAINT BASE

OPERATION 6. ASSEMBLE TUBE

Special Fixtures—Centering fixture. Gages—Length.

Loading

OPERATION 1. INSERT DIAPHRAGM IN TUBE

OPERATION 2. FILL CASE

OPERATION 3. COMPRESS BALLS

OPERATION 4. CUT OUT SURPLUS RESIN

Tools—Universal chuck; steady-rest; resin cutter. Gages-Depth.

The 4.7-In. Common Shrapnel (60 Lb.)

A dimensioned forging of the 4.7-in. common shrapnel is shown in Fig. 4, and a dimensioned case is given in Fig. 5. The complete projectile is illustrated in Fig. 6.

The operations, tools and gages are of practically the same type as for the 3.8-in. size.

The 6-In. Common Shrapnel (120 Lb.)

In Fig. 7 is a dimensioned forging of the 6-in. common shrapnel. A dimensioned case is shown in Fig. 8, and the complete projectile is illustrated in Fig. 9. The operations, tools and gages are of the same type as for the preceding sizes.

The 3.8-In. Common Steel Shell, Model 1905

Fig. 10 shows a dimensioned forging of the 3.8-in. common steel shell, and a dimensioned case is presented

form for point; follower. Gages—Combination snap maximum and minimum rough diameter of bourrelet; projectile profile; profile of point.

OPERATION 4. MILL THREADS IN BASE

Tools—Thread milling cutter; arbor; spring chuck. Gages—Maximum thread plug; minimum thread plug and eccentricity of counterbore.

OPERATION 5. MACHINE BASE-COVER GROOVES

Tools—Toolholder (fixed spindle); four roughing tools; toolholder; fixture on cross-slide with finishing tools; finishing toolholder and two tools. Gages—Inside diameter working gage; diameter depth and width.

OPERATION 6. HEAT-TREATMENT

(A) Heat in furnace; (B) cottonseed-oil bath; (C) heat in lead furnace.

OPERATION 7. FINISH-GRIND BOURRELET

Tools—Electric grinder; special chuck; steady-rest. Gages—Maximum and minimum ring diameter of bourrelet.

OPERATION 8. ASSEMBLE BANDS

Tools—Banding dies; tongs; gas furnace.

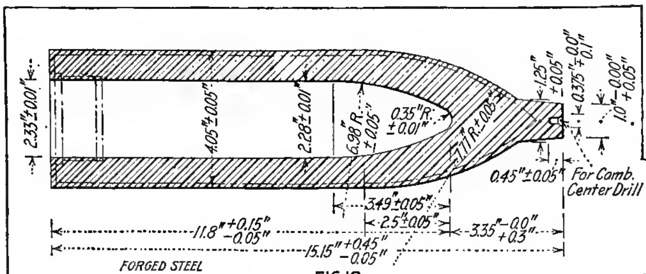
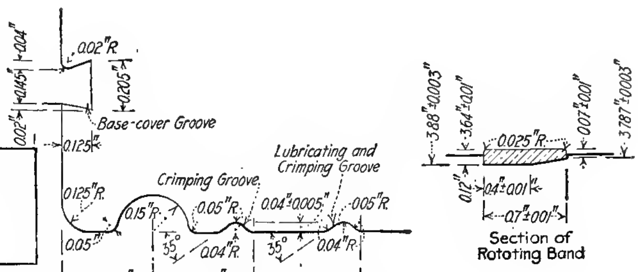


FIG. 10



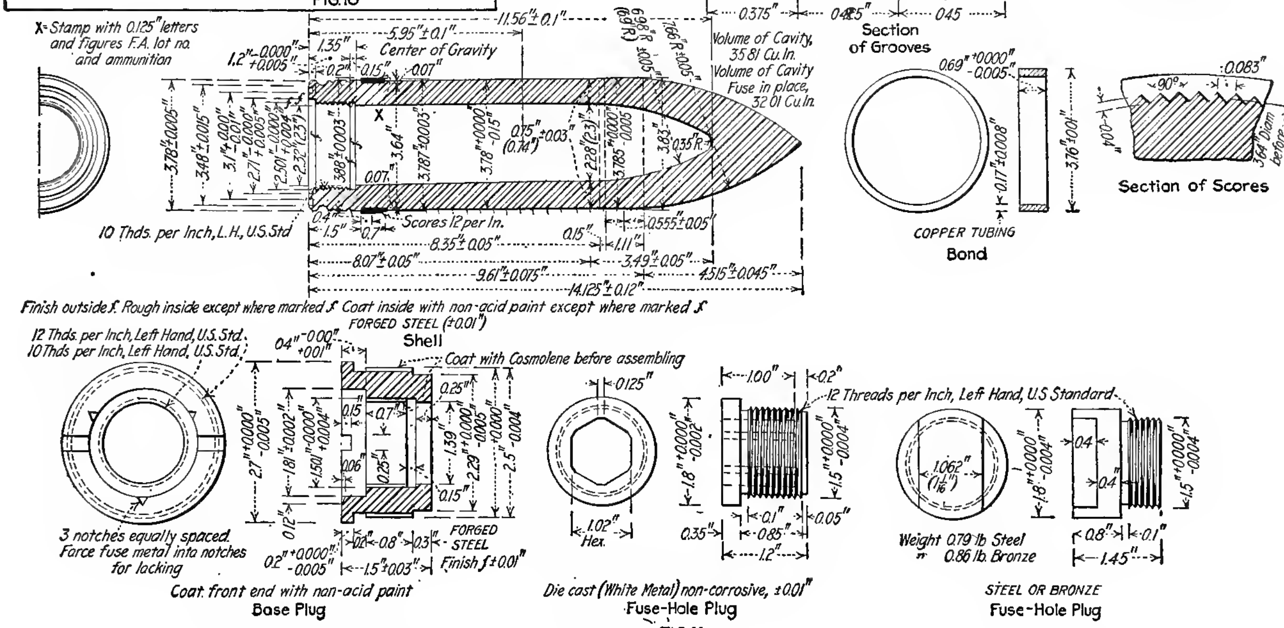


FIG. 11

in Fig. 11. The operations are practically the same as for the 4.7-in. shell.

The 4.7-In. Common Steel Shell, Model of 1905

From Fig. 12 may be obtained the dimensions of the forging for the 4.7-in. common steel shell, while Fig. 13 shows a dimensioned case.

OPERATION 1. ROUGH-TURN BODY

Tools—Universal chuck; revolving center; right-hand lathe turning tool.

OPERATION 2. MACHINE INTERIOR AND EXTERIOR OF BASE AND FINISH-TURN BODY

Tools—Chuck pads; combination counterbore and reamer; recessing tool; circular form tool; knurling tool; right-hand lathe turning tool and holders. Gages—Depth of cavity and warp; base plug flange seat; maximum and minimum ring diameter rear of band; combination snap diameter band seat; position of band seat and crimping grooves; combination snap diameter of body; position of grooves; length of base to bourrelet.

OPERATION 3. FINISH-TURN POINT AND ROUGH-TURN BOURRELET

Tools—Special chuck; steady-rest; left-hand lathe turning tool; former rear of cross-slide; extension bracket and roller;

OPERATION 9. TURN BANDS

Tools—Special chuck; steady-rest; right-hand side-facing tools; band-turning tool; special stop; form and follower rear of cross-slide. Gages—Maximum and minimum ring diameter of band; position and profile of band.

OPERATION 10. HYDRAULIC TEST

Equipment Used—1500-ton heading press with pressure pump; testing fixture; triplex chain drop.

Base Plugs

OPERATION 1. MACHINE FROM BAR

Tools—Stock stop; two twist drills; two drill holders; combination floating counterbore and reamer; forming tool; facing tool; cutting-off tool; chuck pads; feeding finger pads and toolholders. Gages—Maximum and minimum plug diameter of small hole; depth and diameter of counterbore; maximum and minimum diameter of flange; maximum and minimum snap diameter of thread; overall length of base; plug and width of flange; length of thread.

OPERATION 2. MILLING INTERNAL THREAD

Tools—Combination milling arbor and cutter; spring chuck. Gages—Maximum and minimum thread plug.

OPERATION 3. CUTTING EXTERNAL THREAD ON TURRET LATHE

Tools—Threading attachment; chuck; screw for chuck; circular thread cutter; chamfering tool. Gages—Maximum and minimum thread ring.

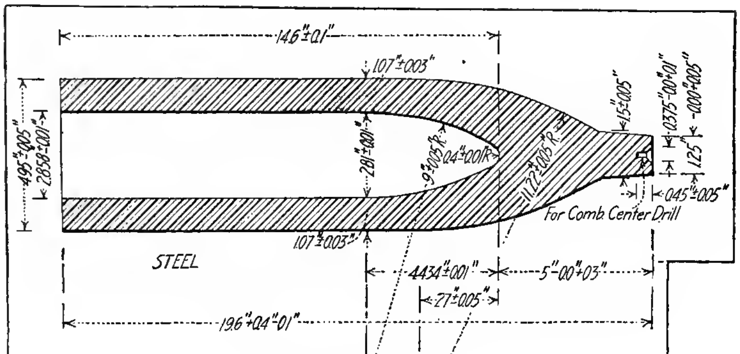
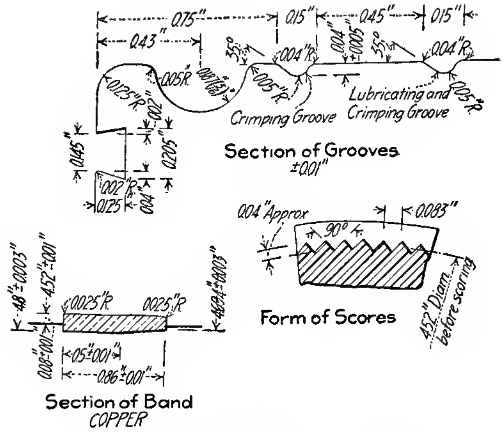


FIG.12



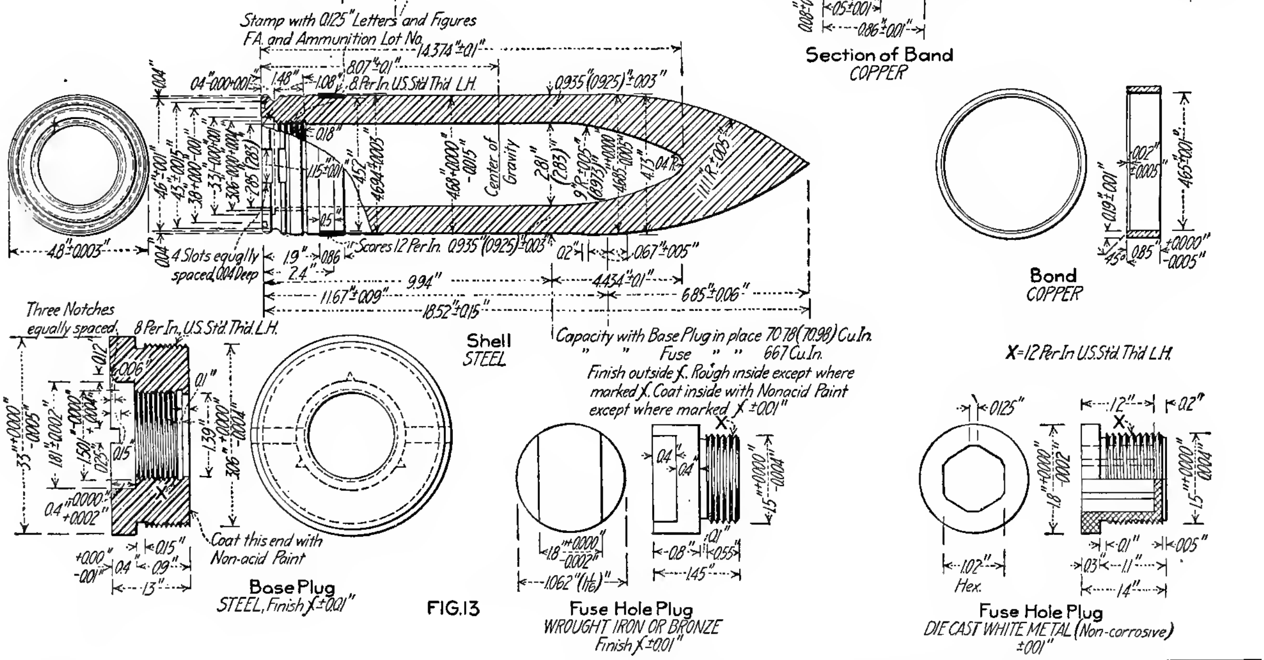


FIG.13

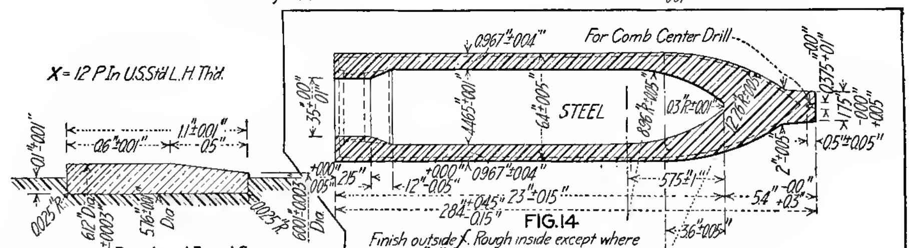


FIG.14

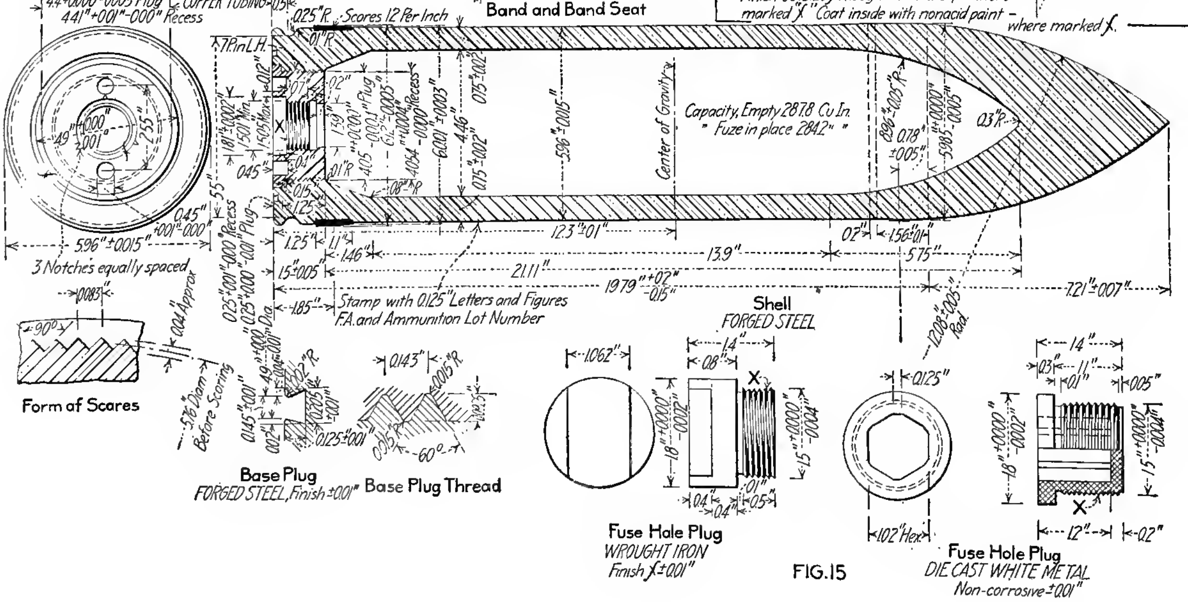


FIG.15

OPERATION 3. CUTTING EXTERNAL THREAD ON THREAD MILLER

Tools—Thread milling cutter; arbor for cutter; spring chuck. Gages—Maximum and minimum thread.

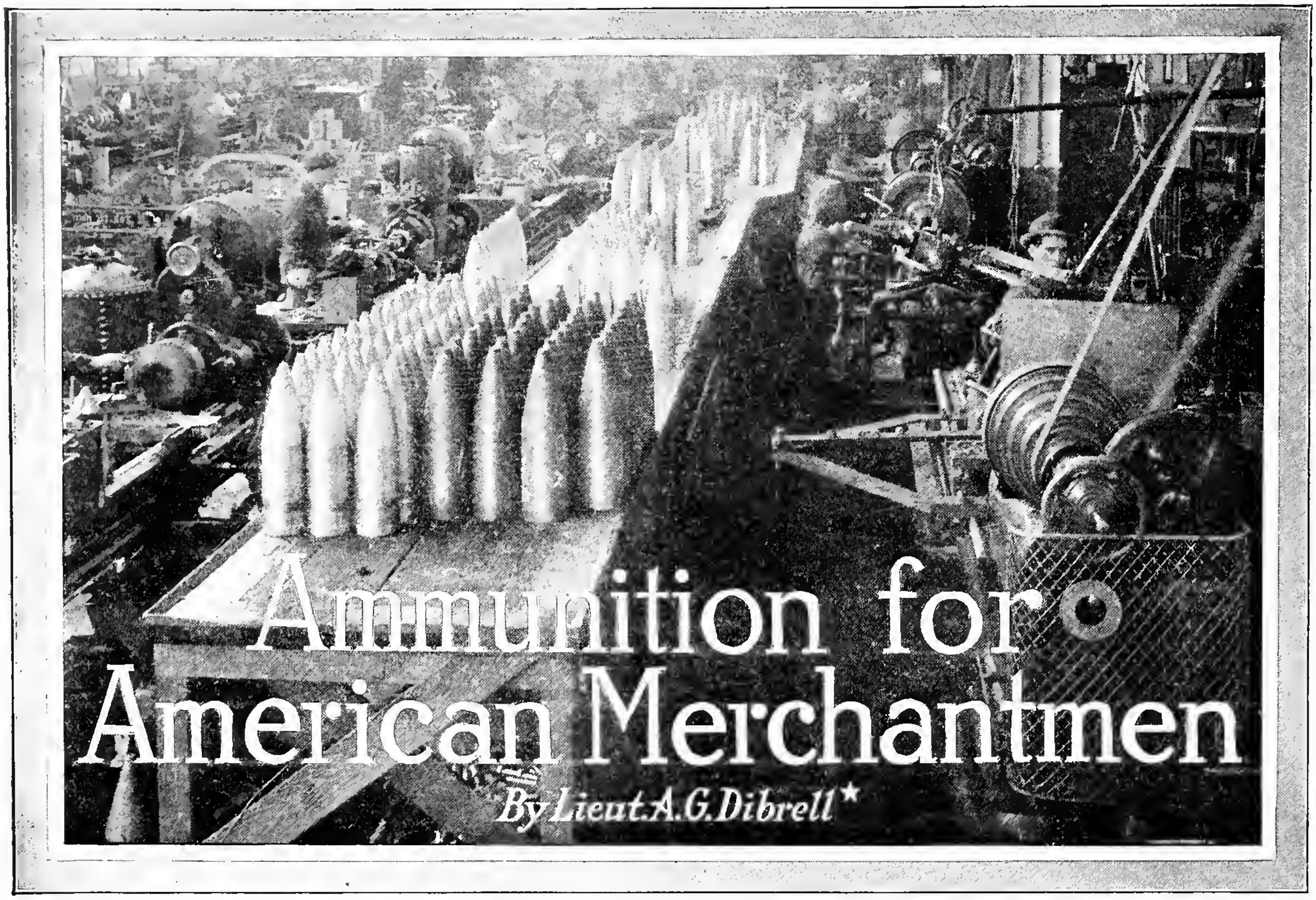
OPERATION 4. NOTCH BASE

Tools—Fixture; milling cutter; arbor.

OPERATION 5. MILLING WRENCH SLOTS

The 6-In. Common Steel Shell

A dimensioned case of the 6-in. common steel shell is shown in Fig. 14. The operations on this shell are practically the same as for the 4.7-in. size.



Ammunition for American Merchantmen

By Lieut. A. G. Dibrell*

SYNOPSIS—The necessity that has forced us to either arm our merchantmen or give up our rights to sail the seas makes necessary the manufacture of shells for the guns to be used on merchantmen. The sinking of the numerous vessels without warning of any kind emphasizes the necessity for arms and ammunition with which to protect our commerce and the lives of American seamen. This article gives in detail the methods used by the navy yard at Puget Sound for making 6-in. common naval shells.

Owing to the great demand made upon this country, many shops are now thoroughly familiar with the process of manufacturing British, French and Russian shells. The United States Navy projectiles differ radically from the army shells of foreign countries and require a departure from the methods of manufacture of foreign shells. As the time for shops to get started on this work may be short in case of war, it is believed that a description of a successful method of machining the navy projectiles will make it possible for contractors to equip their machines by the time forgings can be obtained. Furthermore, the ideas here set forth may enable mechanics in the United States to improve on this method, thereby decreasing the cost and increasing the output. There are three essentials in the machining of projectiles: (1) They must be of a certain weight within a very small tolerance, because a standard weight, or charge, of powder is used and undue variation in the weight of the projectiles affects the range; (2) the center of gravity must be maintained or the projectile will "tumble" in flight; (3) the projectile must be concentric or it will give an erratic flight, causing wide dispersion. These ballistic qualities a shell must have; but just how to obtain them and keep within all the small tolerances allowed in the dimensions is the mechanical problem to be solved. From experience gained at the Puget Sound navy yard, and in other shops visited, it may be stated as a general rule that the ordinary three- and four-jawed lathe chucks cannot be successfully employed in the manufacture of shells. Draw-in, or pot chucks, collet chucks and expanding mandrels must be used. To save the cost of handling, as many operations as possible should be performed at one chucking; and where engine lathes are employed turret heads should be fitted to the crossfeed.

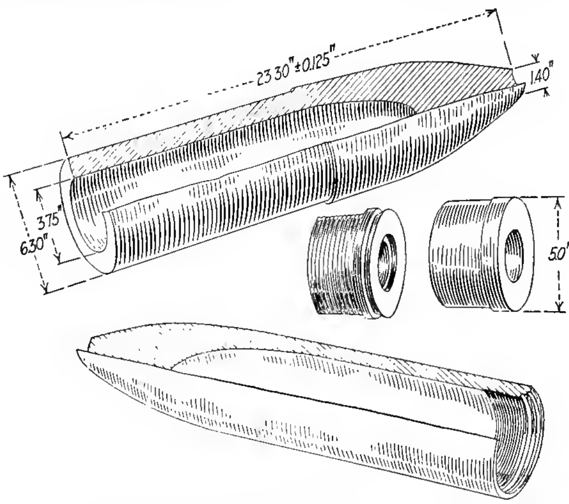
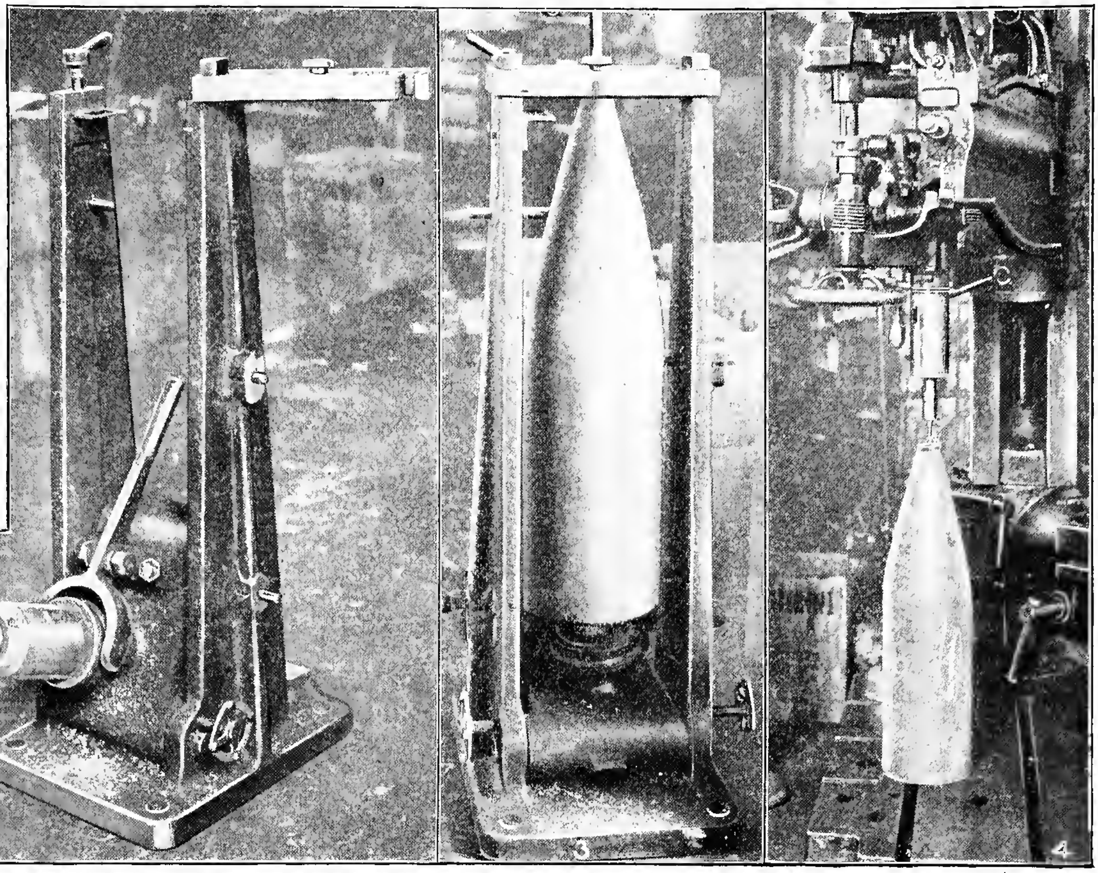
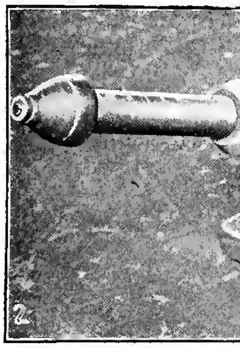


FIG. 1. ROUGH-FORGING AND FINISHED UNITED STATES NAVY 6-IN. COMMON PROJECTILE

*United States Navy, Submarine Division.

Fig. 1 gives the dimensions of the rough forging furnished the navy yard, but not the dimensions of the finished projectile. It was assumed that the steel billets would be punched in the forming dies at one stroke. In that case allowance must be made for the punch running out of true in a great many forgings. Fig. 2 shows the centering and gaging machine. This machine serves two purposes: First, centering the outside of the forging true with the cavity, for rough-turning the outside, and second, determining whether or not there is sufficient stock in the forging for finishing. If insufficient stock is found, or the forging is pierced too much out of center or flat on the radius, it is marked and no machine work is wasted on it. The machine consists of a cast-steel stand with two columns between which the forging is placed for centering and gaging. On top of the column is a swinging arm secured by a handle nut, containing the centering bushing. The stop on the back allows the spindle to tilt about 65 deg. for slipping the rough forging over the spindle

FIGS. 2 TO 4. CENTERING GAGE AND THE METHOD OF DRILLING THE CENTER
Fig. 2—View of centering and gaging rig, operation 1. Fig. 3—Six-inch projectile forging in centering and gaging rig. Fig. 4—Drilling center in 6-in. forging, operation 1

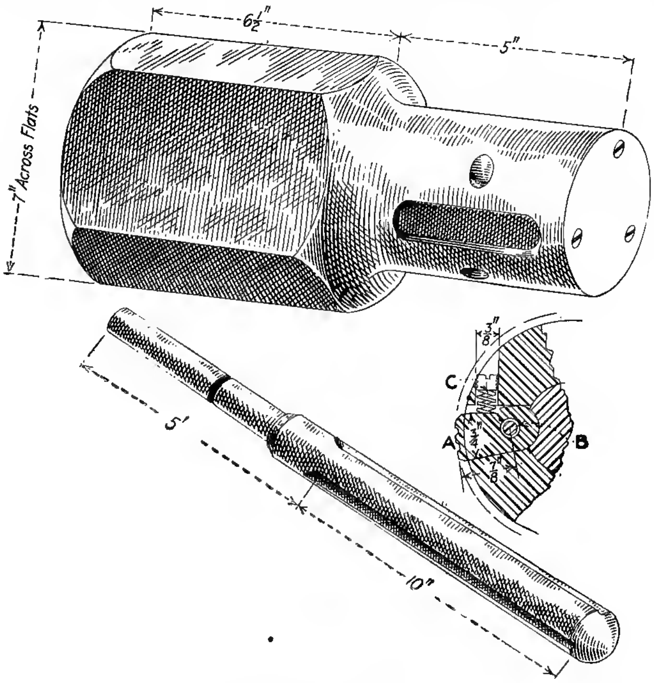


FIG. 5. EXPANDING MANDREL FOR HAMILTON LATHE. OPERATION 2

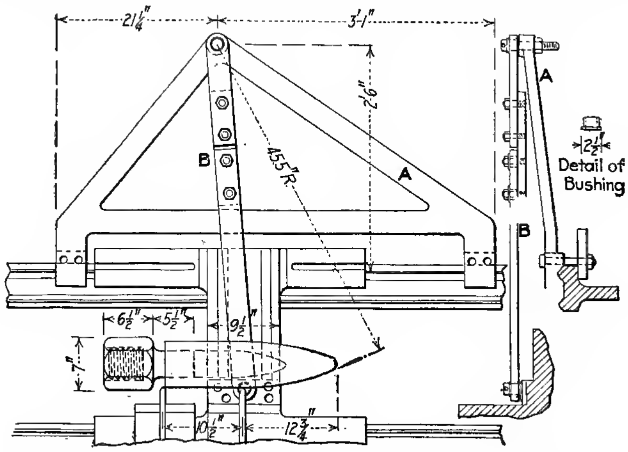


FIG. 6. RADIUS-TURNING ATTACHMENT FOR HAMILTON LATHE, OPERATION 2

The weight of the shell on the cone forces the three rollers out against the base of the forging, firmly holding the forging true with the cavity. The forging is thrown back into the frame and the top plate closed. The forging is removed by the forked handle shown.

A later development was fitted to offset the forgings when too much out of center for the machine. This consists of handwheels on threaded stems operating the base of the spindle and giving an offset of $\frac{1}{16}$ in. Each forging is revolved on

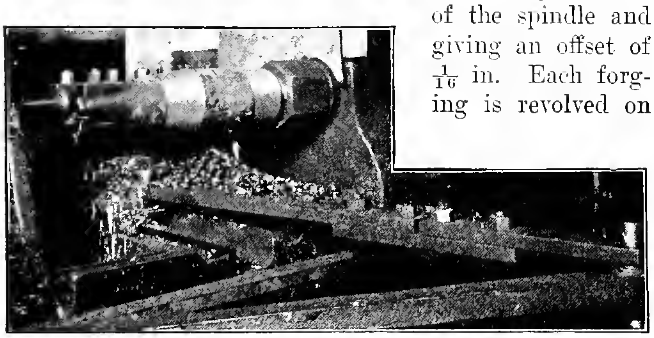


FIG. 7. ROUGH-TURNING 6-IN. FORGING, OPERATION 2

the centering spindle while the movable indicator pins are held against the forging. Should the stock pins, Figs. 2 and 3, show insufficient stock for finishing, the lines on the indicator pins pass beyond the established marks. If the forging is good, it is center-punched through the bushing, as shown in Fig. 3, and the bench mark is established on the base of the forging. The forging is then removed and the center drilled in a radial drill press, Fig. 4. The bushing in the swing lever has recently been enlarged, and the base of the casting is bolted to the press table so that the drilling is done without removing the forging from the centering machine. This operation has been found necessary, as the points of many forgings dropped in cooling. For operation 2, an old 32-in. by 8-ft. Hamilton engine lathe was fitted with an expanding mandrel and a radius-turning attachment. The outside having been centered with the cavity, the forging may be held on a mandrel for rough-turning. The mandrel was designed to grip the inside of the forging firmly, so that it would be rough-turned the entire length concentric with the cavity. The mandrel is made of cast steel and fits over the lathe spindle. The forging is gripped by three dog wedges of tool steel, shown at *A* in Fig. 5, which are held in place by pins and springs, shown at *B* and *C*. These dog wedges are forced out by the medium-steel taper spindle shown. The rod screwed into the taper spindle runs through the hollow spindle of the lathe and is operated by a handwheel. The grip is over a length of 3 in., and the shell is further supported by the tailstock in the center drilled in operation 1.

In order to obtain a heavy cut and prevent chattering of the tool a positive radius-turning attachment was made for the roughing machine, in accordance with Figs. 6 and 7. The frame consists of two arms of cast iron secured to the back of the lathe bed, shown at *A*. The radius arm *B* is of medium steel on a radius of 45.5 in. and is secured to the tool carriage by a composition G-bolt. In order to remove the metal on the roughing cut as quickly as possible, two tools were fitted; one to take the straight cut and the other to begin at the bourrelet and take the radius. Marks are established on the lathe face-plate and a carriage indicator is used for setting each forging correctly. A shell is accurately gaged from this machine once each day to determine whether the tools are properly set and that the forgings are leaving the machine in accordance with instructions.

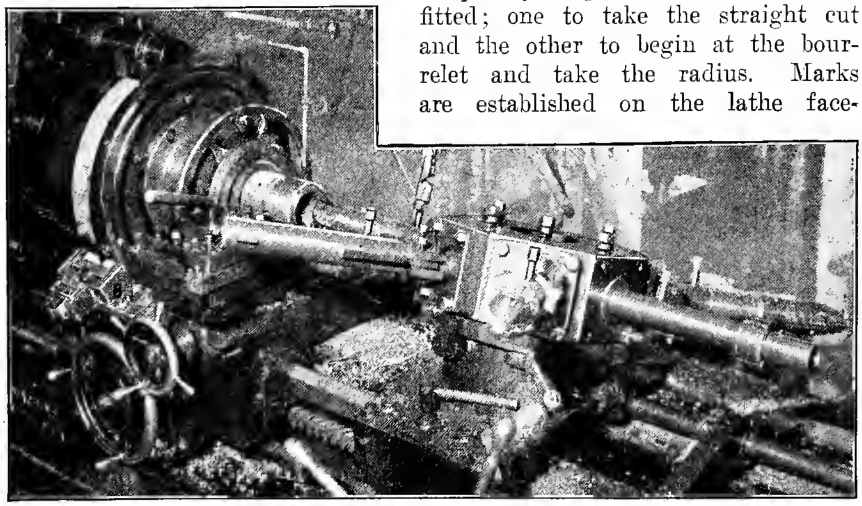


FIG. 9. GISHOLT LATHE FITTED FOR PERFORMING OPERATION 3

The forging is chucked on an expanding mandrel and accurately set with the tram in the bench mark and the established mark on the mandrel nut. The center line of the radius-turning bar is set 7.02 in. from the bench mark established in operation 1; at this point the indicator on the lathe carriage coincides with the established gage on the lathe. With the carriage set in this position, the

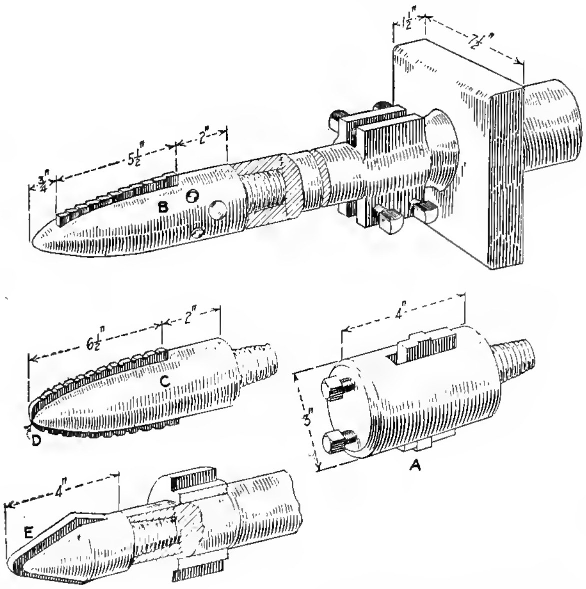


FIG. 8. DETAILS OF BORING BARS AND BORING HEADS FOR GISHOLT LATHE, OPERATION 3

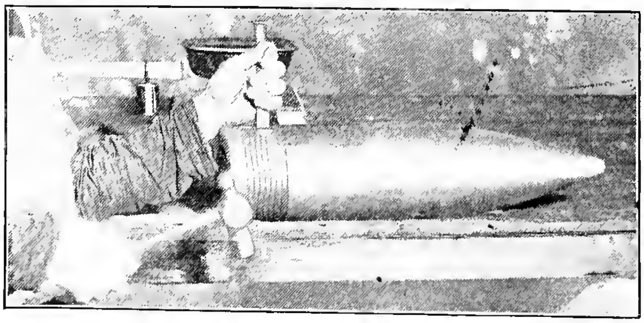


FIG. 10. CUTTING AIR VENTS IN SINUSOIDAL RIBS, OPERATION 4

radius-turning tool is accurately set with gages. The tool for turning the straight body is set 10.5 in. behind the radius-turning tool. The base of the forging is then faced off to the bench mark.

The forgings are $6\frac{1}{2}$ in. in diameter in the rough, and to turn to $6\frac{1}{16}$in. requires a cut of $\frac{7}{32}$ in. on a side. This gives $\frac{1}{16}$ in. to finish. No cutting compound is used in this operation. The cutting tools are made of $\frac{7}{8}$ x $1\frac{1}{8}$-in. tungsten tool steel. A speed of 47 ft. per min. with a feed of $^1/_{28}$ in. is used, and it is necessary to sharpen tools about every sixth shell. This operation is also shown in Fig. 7, which is a view taken from the back of the lathe to show the radius attachment.

The outside having been rough-machined concentric with the cavity, the forging can now be chucked in a universal pot-chuck for boring the cavity. Gisholt turret lathes were the most available for the boring, operation 3, a universal chuck, bolted to the faceplate flange being used. This is a draw-in chuck with a 20-in. wheel, the collet being made in six segments carefully machined. The segments are separated by small springs, which release the forging when the nut is backed off the taper.

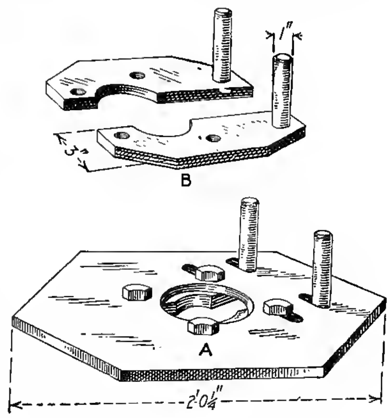


FIG. 11. DETAILS OF PLATE

Fig. 8 shows the special boring bars and cutting heads for the Gisholt turret lathe. The straight head *A* carries the cutting tools for boring, these being made of $\frac{1}{2}$-in. square tungsten tool steel. Two heads were made for each bar, so that the cutting tools could be changed and a reserve head remain always available. The rough-boring bar removes $\frac{7}{32}$ in. of metal, finishing a hole to $3\frac{31}{32}$ in. and leaving $\frac{1}{32}$ in. to be removed by the finishing tool. The forgings are received with an inside diameter of $3\frac{3}{4}$ in. and must be finished to an inside diameter of 4 inches.

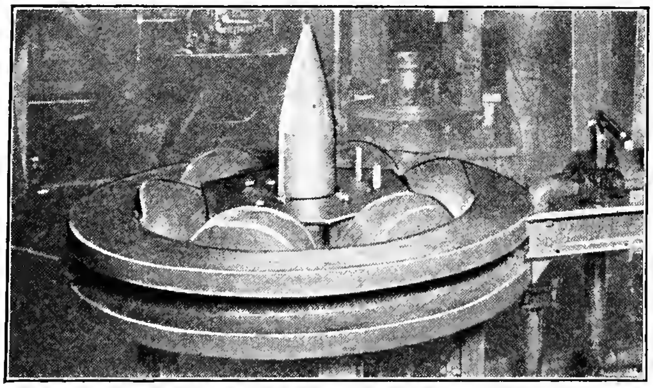


FIG. 13. SIX-INCH PROJECTILE FORGING IN BANDING PRESS, OPERATION 5

The roughing radius head is shown at *B*. The cutters are made of $\frac{1}{2}$ x $\frac{1}{2}$-in. and $\frac{1}{2}$ x 1-in. tungsten tool steel and the lengths of cutters vary as shown in the illustration. These cutters are designed to remove the maximum amount of metal that the machine will pull. The finishing head is shown at *C* and the finish cutters at *D*. These cutters leave a clean, smooth surface. The point of the shell is finished by the cutter *E*.

The Cutting Compound

In order to obtain cutting compound on the point of the cutting tool $\frac{3}{8}$-in. holes (not shown in the drawing) were drilled through the bars, the discharge opening being in the heads. A plug was fitted to each bar and the flexible hose connection made by means of a bayonet joint. This is shown in Fig. 9. The cutting compound is a mixture of 2 lb. of borax dissolved in 10 gal. of boiling water, to which is added 2 gal. of boiling lard oil. The tools require changing about once a day or about every tenth forging. Each bar is fitted with an independent stop and these are tested and adjusted once daily. A boring speed of 30 ft. per min. with a feed of $^1/_{40}$ in. per revolution is used. In addition to the boring operations a turret head is fitted on the tool carriage of these lathes to carry tools for cutting the copper band groove, undercutting, cutting the sinusoidal rib and rounding the base. The band score is first rough-cut to a diameter of 5.8 in.; then the sinusoidal cam is thrown in and the groove finished to 5.7 in. at the bottom. The undercutting is done next and finally the base of the shell is rounded. This requires four tools on the turret head of the tool carriage, these operations being completed during the boring. The sinusoidal rib-cutting cam arrangement is shown in Fig. 9. The cast-iron camplate *A* is bolted to the faceplate of the lathe, and the cast-iron plate *B* is fastened to the lathe carriage. The medium-steel arm *C* con-

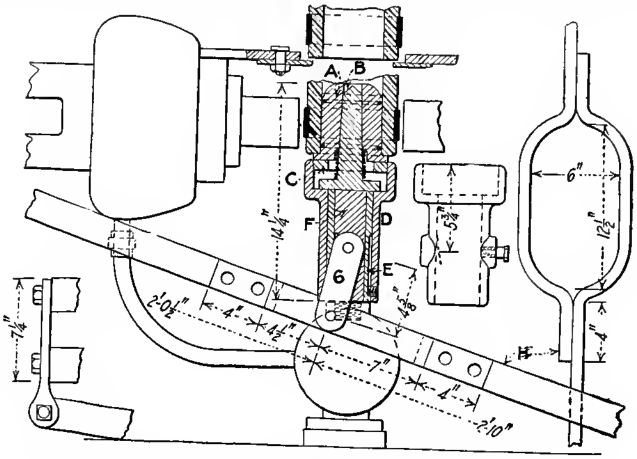


FIG. 12. DETAILS OF MANDREL AND EJECTOR FOR BANDING PRESS, OPERATION 5

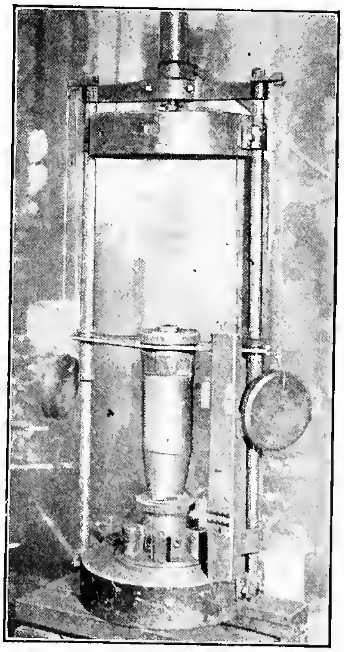


FIG. 14. MARKING BASE, OPERATION 6

nects the two pieces, the cam motion being positive, by means of casehardened rollers on each side of the cam-plate.

Operation 4 consists in cutting air vents in the sinusoidal ribs, Fig. 10. The copper band is slipped over the base and struck a blow with a wooden mallet to seat it in the groove, operation 5.

Experiments conducted after the arrival of the banding press indicated that the base of the forging was crushed in about 0.015 in. in banding. To prevent this a special mandrel was designed, Figs. 11, 12 and 13. A large hexagonal ½-in. plate *A*, Fig. 11, was fitted inside of the rams of the press. Through this plate a hole was cut 7 in. in diameter. Underneath this plate are fitted two hinged plates *B* with lugs sliding in slots cut in the upper plate *A*. The diameter of the plate *B* is 5⅝ in. A spring slips over the lugs to hold the plate in place while the shell is being put in and taken out of the press. The spring and the lugs are better shown in Fig. 13.

In Fig. 12, *A* is an expanding mandrel of medium steel which slips into the base of the forging and is forced out against the inner walls by the taper spindle *B*. *C* is a screw bushing which screws into the telescopic sleeve *D*. The guide for the mandrel is operated by a hand lever. This guide works in the inner sleeve *E* of the telescope. The action is as follows: The plates *B* are closed and locked by the spring. The forging is set on its base on this plate and the mandrel handle lifted, forcing the mandrel into the cavity. The plates *B*

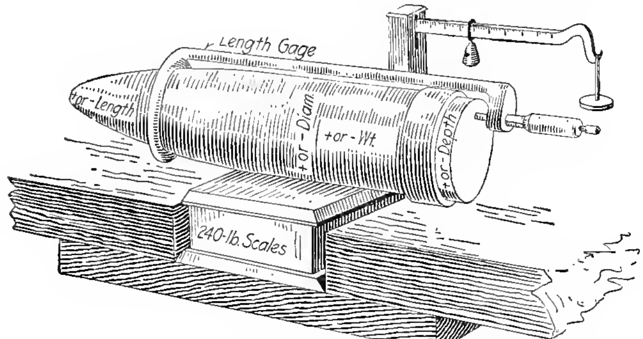


FIG. 15

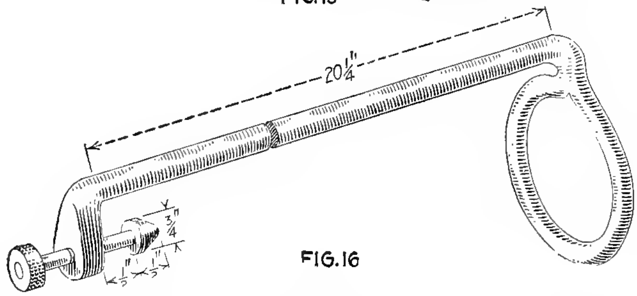


FIG. 16

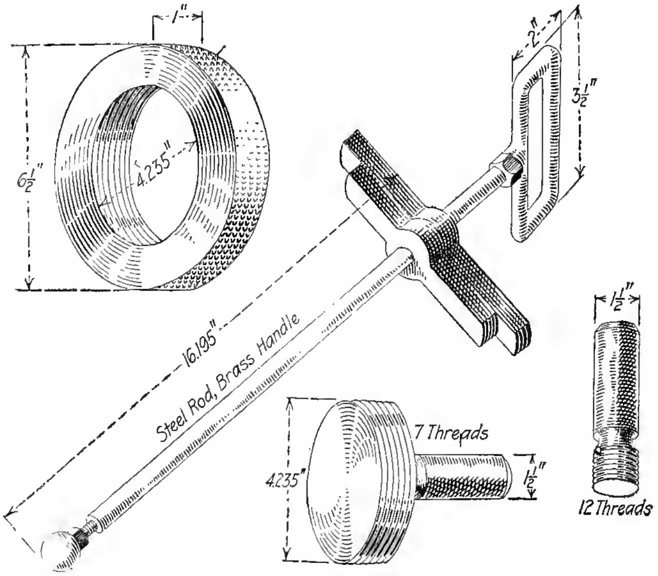


FIG. 17

FIGS. 15 TO 17. GAGES AND METHOD OF WEIGHING FOR OPERATION 7

Fig. 15—Measure weight and gage, operation 7. Fig. 16—Details of gage for operation 7. Fig. 17—Depth gage used in operation 7 and gages for base and base plug

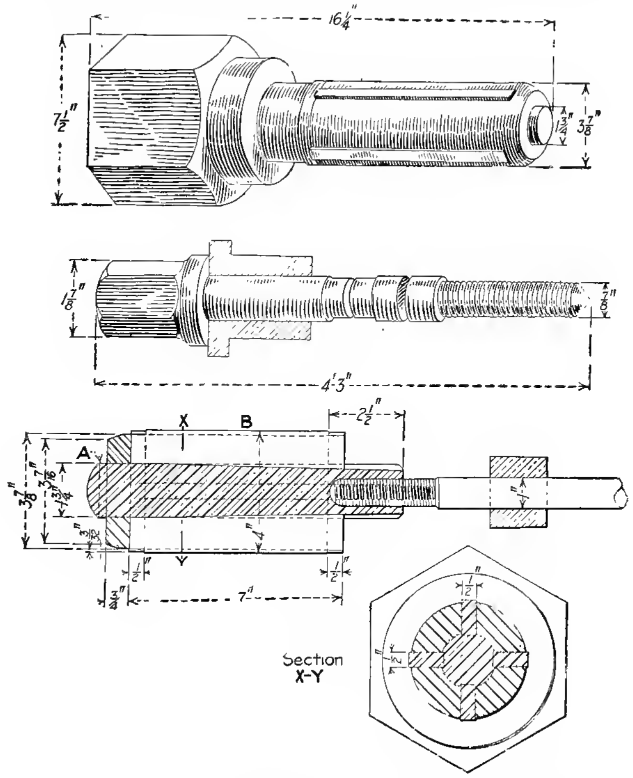


FIG. 18. EXPANDING MANDREL FITTED TO LE BLOND ENGINE LATHES FOR FINISH-TURNING, OPERATION 8

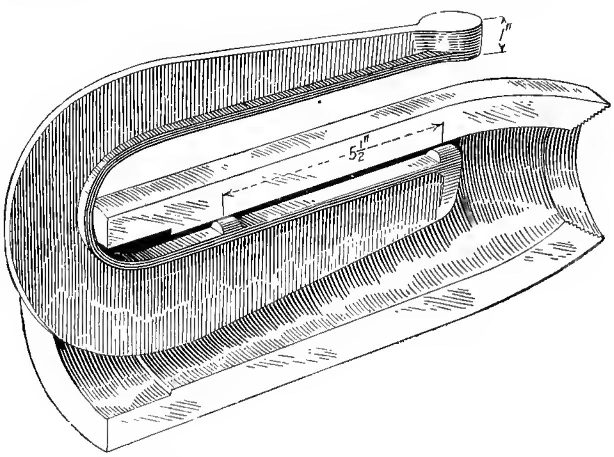


FIG. 19. GAGE FOR DETERMINING ECCENTRICITY OF WALLS, OPERATION 8

are thrown out and the forging lowered to the banding position, which is determined by a stop. The band is given four squeezes of the press, the forging being slightly

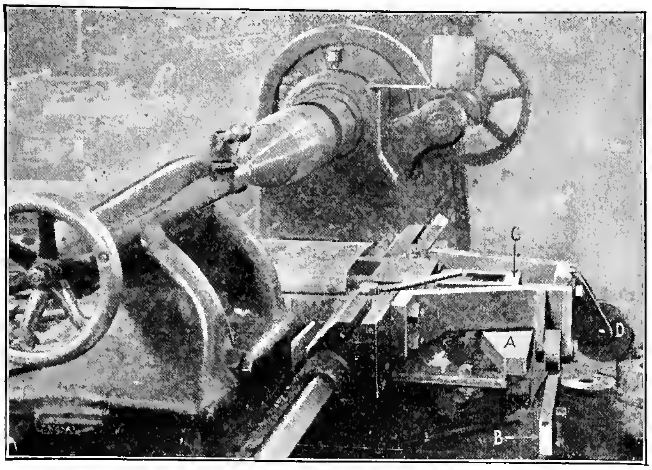


FIG. 20. FINISH-TURNING, SHOWING RADIUS ATTACHMENT, OPERATION 8

rotated after each squeeze. A gage pressure of 2500 lb. is applied, which gives a total pressure of 100 tons on the copper band. The hand lever is again lifted, the plates *B* thrown under the base of the forging, and the mandrel withdrawn. The device for marking the base, operation 6, consists of a cast-iron base to which are secured the two uprights, Fig. 14. The dieplate containing the letter die slides up and down on the uprights. The dieplate is secured to the base of the shell by means of a setscrew. The counterweights lift the die and plate after marking. On the base of the marker is mounted a conical chuck for taking the nose of the forging, which is protected from burrs by thin copper sheets. On top of the uprights is a yoke supporting the air-hoist cylinder, which lifts the weight after the blow has been delivered. The weight, when released by opening the air-exhaust valves, drops by gravity. The letters shown in the pocket at the right are for marking the lot and serial numbers by hand. The forging is taken from the band-

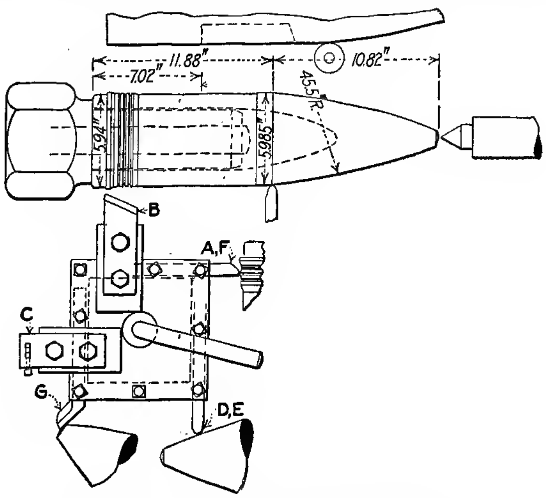


FIG. 21. FINISHING, OPERATION 8

ing press and set nose down in the chuck shown. The letter die in the dieplate is placed over the base of the shell and the weight of 550 lb. dropped from a height of 2 feet.

The forging is next weighed and gaged in accordance with Fig. 15. The length is taken by the gage shown in Fig. 16 and the depth of cavity by the gage shown in Fig. 17. The diameter is taken with micrometers and all the dimensions are marked on the forging as indicated in Fig. 15. The forging, therefore, goes to the finishing lathes, operation 8, with the necessary information for an accurate finish. The man in charge of the job checks the gaging, operation 7, before the finish-cuts are taken.

Fitting 24-in. LeBlond lathes for finishing the forgings, operation 8, was one of the most difficult and costly equipments made. Referring to Fig. 18, the mandrel block was first made of cast steel; but the castings would either take a set or be so porous that they would spring. The block, as fitted at present, is made of forged steel. This block screws over the hollow spindle of the lathe. Through the hollow spindle from the back of the lathe runs a forged steel rod that screws into the expanding mandrel *A*, which is made of forged steel casehardened. The jaws *B* are of tempered tool steel and are 7 in. long, thus giving a grip practically the entire length of the cylinder cavity.

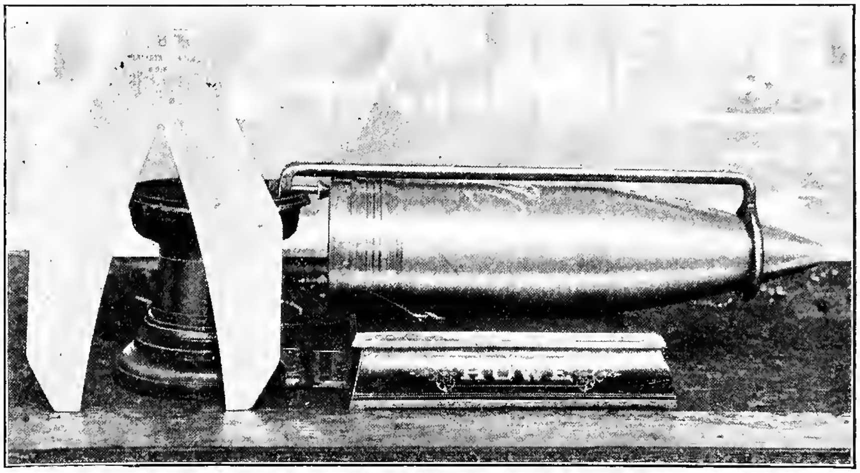


FIG. 22. WEIGHING AND GAGING, OPERATION 8

The diameter of the jaws is slightly less than 4 in., enough to enter the forging, and is accurately ground to size. A handwheel at the end of the lathe fits the mandrel nut. By turning this wheel the mandrel *A* is drawn back, the taper forcing the jaws *B* hard out against the cavity of the shell and giving a good grip. The mandrel is tested daily for trueness; a few forgings are tested daily for eccentricity by means of the gage, Fig. 19. The maximum eccentricity obtained was 0.015 in.; the average is about 0.005 in. This small eccentricity is due to the spring in the turret head when an exceptionally hard forging is being machined. The cutting tool being at the corner of the turret does not give the required stiffness when working on hard forgings.

These lathes were not large enough to fit a positive-acting radius-turning arm similar to the one fitted to the Hamilton lathe for the rough-turning, so the profiling attachment shown in Fig. 20 was designed. The cast-iron radius form *A* is bolted to the taper attachment at the back of the lathe. A cast-steel guide bracket is bolted to the tool carriage. Other brackets are bolted to the bedplate at the back of the lathe and support the bar *B,* which acts as a trolley for the rollers of the guide bracket. The cast-steel roller bracket *C* inside the guide bracket is bolted to the crossfeed screw. A $\frac{3}{8}$-in. wire cable is attached to the roller bracket, is led over the pulley *D* and made fast to a 200-lb. weight at the back of the lathe. The base-plug forgings shown in the photograph were added to increase the weight. The design works perfectly on ordinary forgings, but some of the forgings are so hard that the pull is insufficient to hold the tool to a full cutting depth. This tendency of the tool to leave the shell has been overcome by using a second plate and roller below the one shown, with the curve away from the lathe. When the roller tends to leave the radius form the second form takes the pressure. A spring was tried out, and it worked well when the tension was maintained, but some operators were careless and the form was substituted for the spring. The turret head fitted to the tool carriage of these lathes is an ordinary square turret head made of cast steel and is secured in the desired positions by means of the lock screw. The wide copper cutting tool and gang tools for cutting the grooves in the copper band are secured near the middle of the side, while the steel cutting tools are secured at the corners. Referring to Fig. 21, the sequence of operations and tools used is as follows: Cut groove in rear of copper band, tool marked *G;* shape copper band, tool *B;* cut grooves in copper band, tool *C;* remove burrs and finish copper band to size, tool *B;* turn bourrelet and radius, tools *D* and *E;*

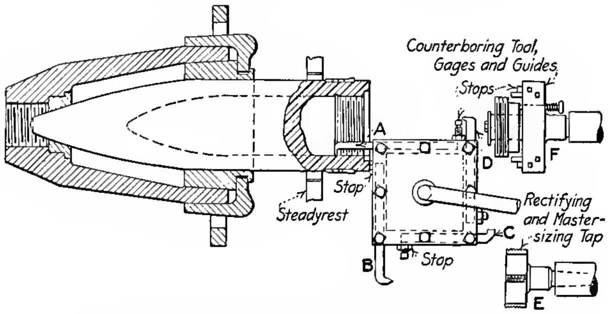


FIG. 24. TOOLS USED IN THREADING THE BASE OF 6-IN. PROJECTILES, OPERATION 9

remove shell, weigh and gage as per Fig. 22, correct weight by turning cylinder of shell between copper band and bourrelet, tools *A* and *F;* turn point of shell, tool *G,* reweigh and mark weight on shell. Turning tools *D, E, A, F* and *G* are of $\frac{3}{4}$ x $1\frac{1}{8}$-in. Midvale tool steel; *B* is of carbon steel $2\frac{1}{4}$ x 1 in.; the gang tools *C* are of tungsten special. The cutting compound previously described is used in these machines. The speed of each machine is 80 r.p.m. and the feed $^1/_{40}$ inch.

The 18-in. by 8-ft. LeBlond lathes were fitted with collet chucks for cutting the threads in the base of the forging, operation 9. These chucks are similar in design to those fitted to the Gisholt turret lathes. The chuck head screws on the lathe spindle instead of bolting to the faceplate, as with the Gisholts. The other features of the design are similar in all respects to those described for the Gisholt machines. On account of the weight of this chuck and the great overhang (17 in.), the steady-rest shown in Fig. 23, is used. The turret head for holding the tools is similar to the one used in operation 8. In this design, however, all the tools are held at the corners and the head is bolted to the crossfeed for working in the cavity of the shell.

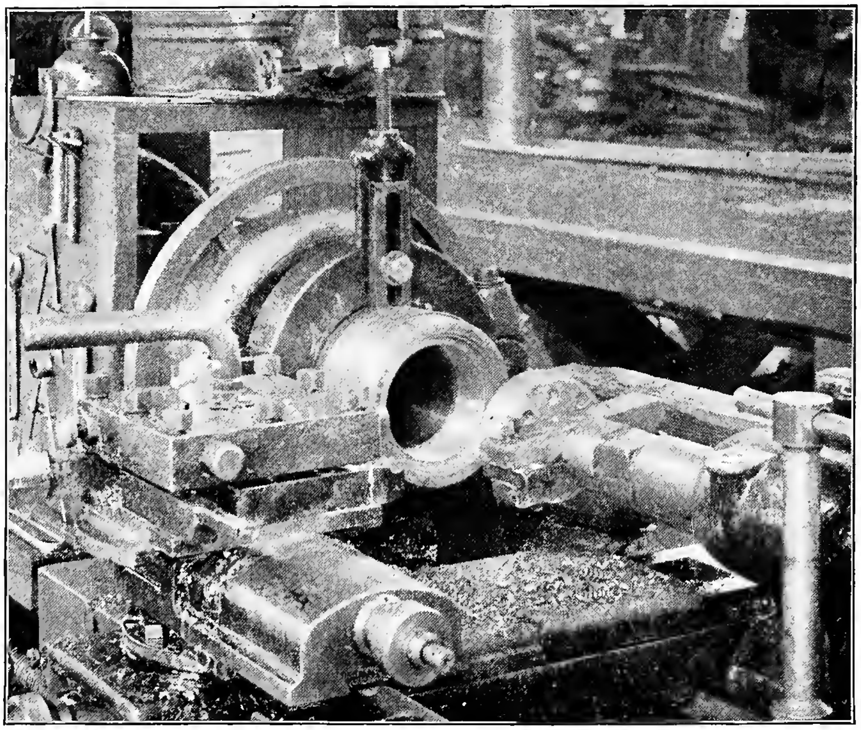


FIG. 23. THREADING THE BASE IN A LE BLOND LATHE, OPERATION 9

Fig. 24 shows how the shell is held and how the turret head is fitted with cutting tools and stops, also the sequence of operations in threading. A chasing tool with six chasing threads has been substituted recently for the single-point thread-cutting tool *B,* and tool *C* has been fitted with a lip that cuts the counterbore for the base plug, so that the counterboring tool on the tailstock is more of a forming tool. These changes were made to increase the production. The tool *A* is shown in the shell;

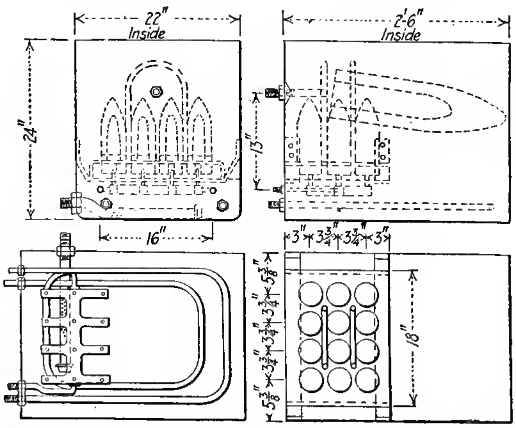


FIG. 25. TANKS AND NOZZLES FOR WASHING 3- AND 6-IN. PROJECTILES, OPERATION 10

the head revolves clockwise. The sizing tap *E* and the master rectifying tap are inserted in the tailstock. The sizing counterboring tool is shown at *F*.

The projectile is next thoroughly washed in a boiling solution of soda and lye water to remove all oil and grease, operation 10. Fig. 25 shows the tanks fitted for both 6- and 3-in. projectiles. The pump shown on the column in Fig. 26 forces the boiling mixture through the

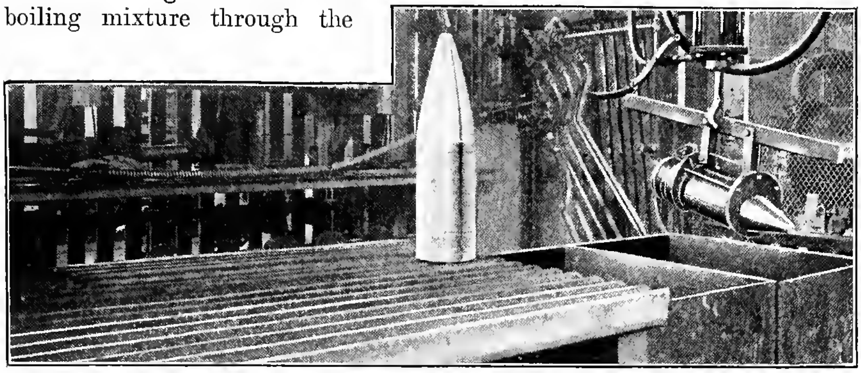


FIG. 26. VIEW OF WASHING TANKS AND DRAIN BOARD, OPERATION 10

spraying nozzle shown for washing the cavity. This illustration also shows a forging in the tongs just lifted from the washing tank by means of the air cylinder. This air cylinder travels on an overhead trolley. The shell is next suspended in the second tank, which contains clear, boiling water for rinsing.

The lacquering, operation 11, as originally designed was to be done on a tipple. A thread guard bushing was screwed in the base, the lacquer poured in hot, the shell revolved and the lacquer poured out. The guard did not prevent the lacquer running into the threads. Also the time required for screwing the bushing in and out was as much as was required when using a brush and painting by hand. No time is lost, because another shell is being washed while the lacquering is being done.

The base plugs are next installed, operation 12, the projectile is dropped into the swinging chuck shown in Fig. 27 and the base plug screwed in by means of a special

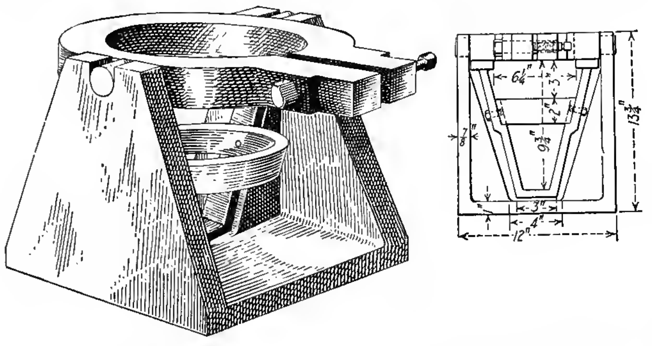


FIG. 27. TRUNNION STANDARD CHUCK FOR INSTALLING BASE PLUGS, 6-IN. PROJECTILES, OPERATION 12

wrench which fits the two holes. Fig. 28 shows the layout of these tables and the sequence of operations. After the plug is installed, the forging is weighed on the scales shown and the final weight is stamped on the base by hand. The number of the plug is also stamped by hand to agree with the number of the projectile. This illustration also shows the painting rig, operation 13, at the left. Briefly, it consists of a constant-speed motor which runs at 1200 r.p.m. and is geared down to drive a conical disk at 88 r.p.m. A swinging arm carrying a cast-iron cone on each end is so centered that when revolved by hand, these cones will alternately engage the driving disk. A spring stop is provided for holding the arm in place while the shell is being painted. While one shell is being painted, the shell that has already been painted is removed from the idle disk by the tongs, Fig. 29, and a fresh shell put on. From here the shell goes out to the shipping station, where it is given its final inspection and stamped before being racked. The only special equipment made for machining the base plugs was a mandrel for finish-turning the outside of the plugs; this mandrel was fitted to the engine lathe. Operation 14 consists in rough-turning the face and body of the base plug. The forging is held by the flange in a four-jawed chuck of a 2-in. Jones & Lamson turret lathe. The inside face of the base plug is first turned to about 1$\frac{23}{32}$ in. from the inner face of the flange. Next the thread space is turned the entire length, leaving the diameter of the forgings about 4$\frac{1}{4}$ in.; 100 forgings are finished in this operation and the machine is then changed for operation 15. The forging is chucked on the thread space and the flange and the fuse hole finished.

A small drill press is used for drilling the holes in the base plug for the spanner wrench, operation 15. The forging is bolted to the table and two $\frac{1}{2}$-in. holes drilled, stops for depth being used.

The base plugs are threaded, operation 16, in a Le Blond engine lathe, a special mandrel being employed.

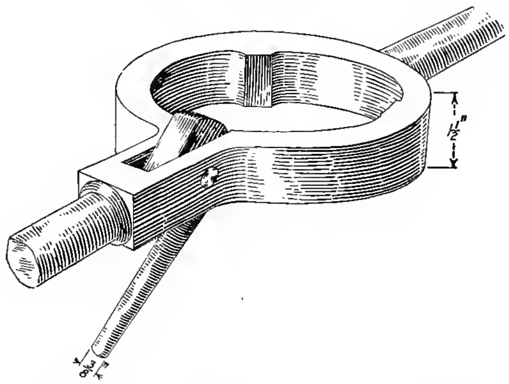


FIG. 29. DETAILS OF TONGS USED IN HANDLING FRESHLY PAINTED 6-IN. PROJECTILES, OPERATION 10

The flange is turned to 4.748 in. in diameter and faced to a thickness of 0.35 in. The thread relief and the threads are then cut 7 thread, left hand, U. S. S. form, each plug being tested with a ring gage. The plugs are fitted in projectiles in operation 8. The cost of equipping all the machines was less than $5000, including labor and indirect and material charges. All the special equipment was installed and the machines ready to start work when the first shipment of forgings was received.

The manufacture of projectiles at the Puget Sound navy yard is secondary to the regular routine repair work on ships and only a few machines were utilized. The output of eleven machines is 18 projectiles per 8-hour day and the average cost for direct labor $1.75 per shell.

In view of the large amount of detailed information already published in these columns on the making of projectiles of various sizes, it has not been considered necessary to go into the minute details of each and every operation. The operations described and the equipment shown will, however, give sufficient information to enable anyone to proceed with the work with very little delay and with comparatively slight modifications of his present equipment. With these methods as a basis and the information as to cost as a guide in making estimates, there should be no delay in getting contracts started, should a large supply of shells become necessary, as now seems likely to be the case. By carefully studying the needed modifications of standard machines, it will be found that these changes can probably be made before forgings can be obtained.

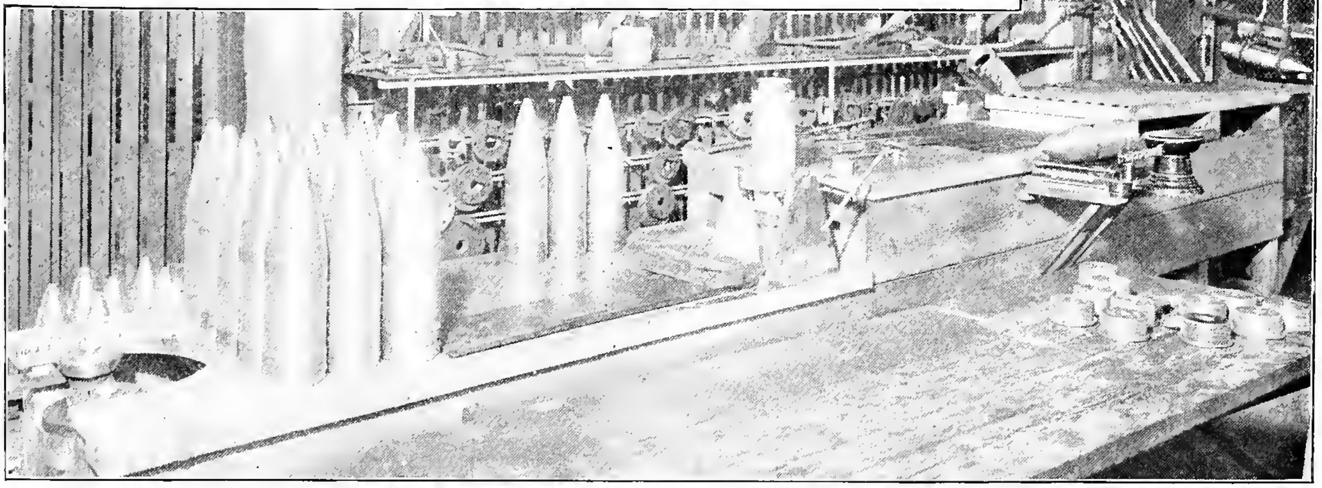
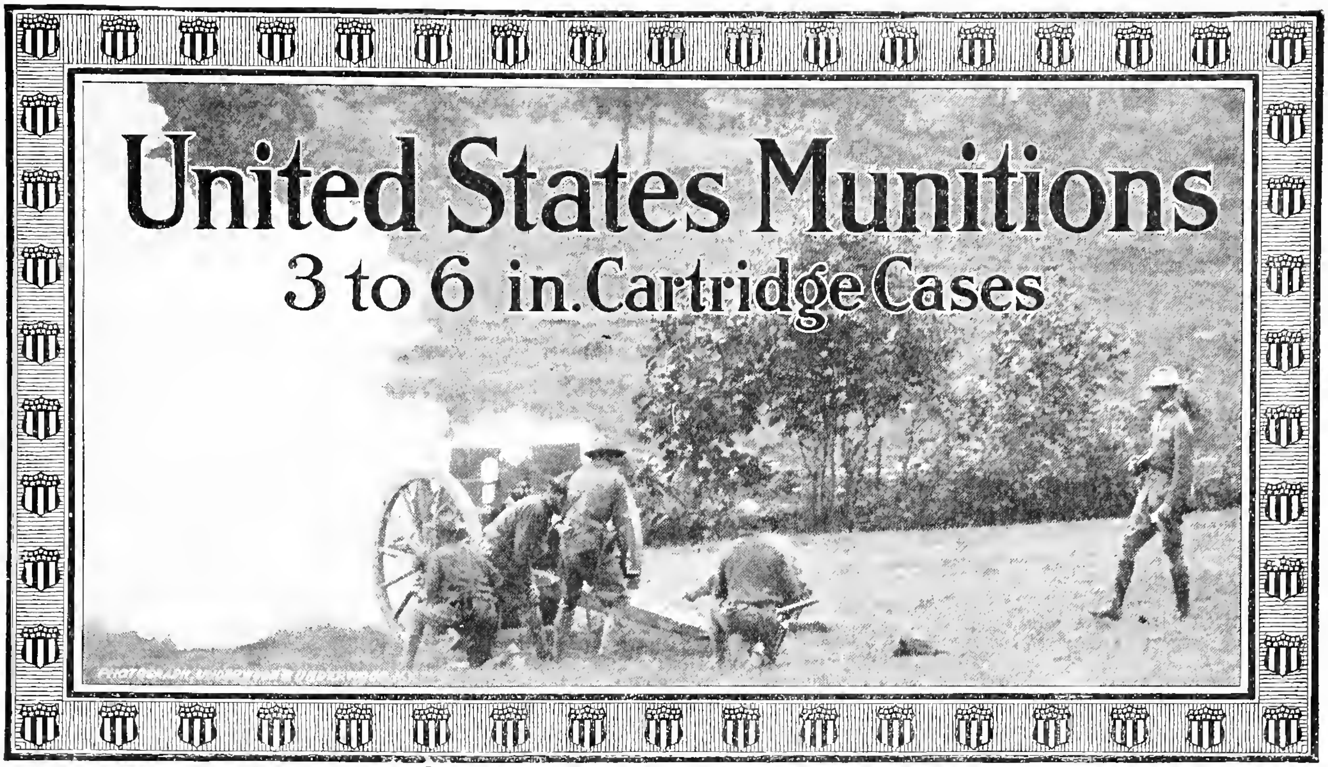


FIG. 28. WASHING, LACQUERING, INSTALLING BASE PLUGS AND PAINTING

United States Munitions
3 to 6 in. Cartridge Cases



The Ordnance Department requirements for brass cartridge cases of all types used by mobile artillery are given in the following specifications:

1. All cartridge cases will be constructed in accordance with drawings provided or approved by the Chief of Ordnance, and no deviation therefrom will be allowed without his authority.

2. The necessary working gages, templets, etc., will be furnished by the contractor except such as the Ordnance Department may furnish for inspection purposes exclusively. The working gages furnished by the contractor will conform to the inspection gages.

3. The manufacture of the articles contracted for and of all material therefor shall be open to inspection by the officers and employees of the Ordnance Department assigned to duty for that purpose and shall in all its details and in all its stages receive the approval of the inspector or such of his assistants as he may designate.

4. A lot of cartridge cases of calibers up to and including 3.8 in. will consist of 20,000 cases. A lot of cartridge cases of 4.7 in. or greater diameter will consist of 10,000 cases.

5. Before beginning the manufacture of cartridge cases in quantity, the contractor will be required to demonstrate to the satisfaction of the inspector, in the case of at least one caliber, by the actual firing test prescribed below and by microscopic examination that he has established such methods of manufacture as will produce cartridge cases that will be satisfactory in service and of a crystalline structure in all parts satisfactory to the inspector.

6. This ballistic test will consist of firing three cases, five rounds each, at a pressure 12 per cent. above the maximum powder pressure allowed by the powder specifications in the particular gun or howitzer for which the cartridge cases are intended. The cases will be resized after each round; and after five rounds have been fired and the cases have been resized four times, none of them shall show longitudinal or transverse cracks, bulges or other defects that will prevent complete obturation or in any other way affect their serviceability for further use.

7. If during the firing any case swells to such an extent that it cannot be extracted by the service extractor of the cannon, it shall be considered unfit for further use.

In addition to the preliminary ballistic test prescribed in the preceding paragraphs, not less than five cases will be sectionalized and microscopically examined to determine whether the various mechanical operations and subsequent heat-treatments have been such as to leave the crystalline structure of the material in proper condition for storage. These sectionalized cases will also be examined to see whether the walls or heads of the cases show any folds either external or internal

8. As the object of the preliminary test is to determine whether the manufacturer has so regulated the mechanical and heat-treating operations as to produce satisfactory cases, and as it is not a question of accepting or rejecting a lot as the result of this test, any further preliminary tests that he may desire will be made at his expense.

9. An analysis will not be required of the materials used in making the brass, but the finished brass will be analyzed and must in all cases show a total copper and zinc content not below 99.88 per cent. with a lead content not above 0.12 per cent. and an iron content not above 0.02 per cent. with negative results as to tin, antimony, bismuth and cadmium.

Any spelter and copper that will give the above results may be used by the contractor at his own risk subject to the chemical, ballistic and microscopic tests herein prescribed.

The chemical analysis of the brass used in cartridge cases 3.8 in. in diameter and under will have a copper content of 68 per cent. plus or minus 1 per cent. and a zinc content of 32 per cent. plus or minus 1 per cent. The brass used in cartridge cases of 4.7-in. diameter and larger must show a copper content of 70 per cent. plus or minus 1 per cent. and a zinc content of 30 per cent. plus or minus 1 per cent.

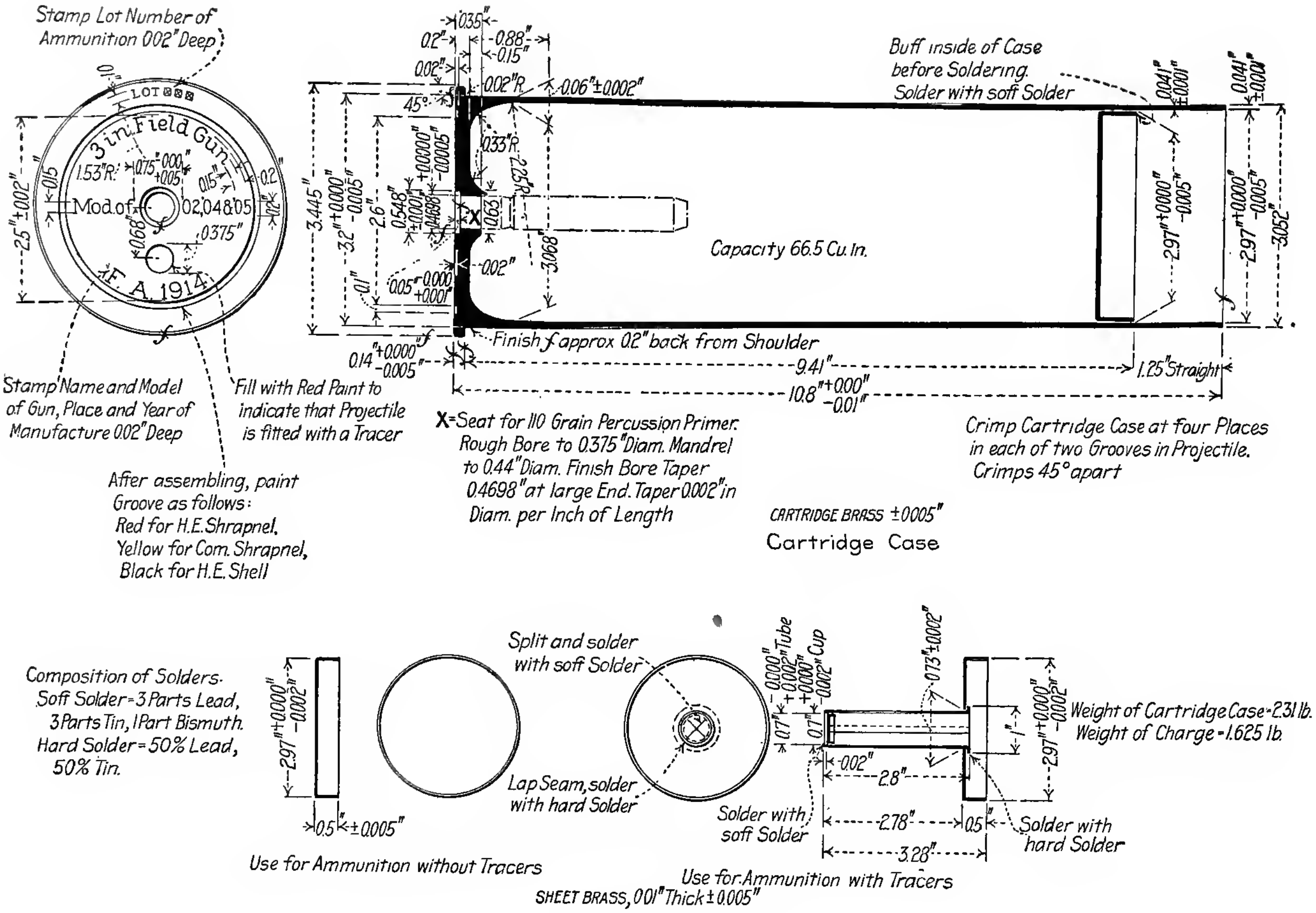
10. Eight cartridge cases will be selected from each lot for microscopic examination and a chemical examination and for ballistic test. Five of these cases will be sectionalized, polished, etched and examined microscopically to determine the crystalline condition of the material. Chemical samples for analysis will also be selected from these five cases. The remaining three cases will be subjected to the same ballistic test as prescribed for the preliminary test in paragraph 6 above.

11. Should any or all of the cases selected fail on the ballistic test, the contractor is entitled to a retest at his own expense. In this event five cases will be selected by the inspector, and the ballistic test as prescribed above will be repeated. If the retest is satisfactory as to all the cases, the lot will be accepted; and if not satisfactory, it will be finally rejected and no further retest allowed.

12. The contractor must have at his works or convenient thereto the necessary apparatus for making the chemical analysis prescribed and must in addition have a satisfactory, modern, metallurgical microscope and the necessary equipment to enable microscopic examination of the metal in the cartridge cases to be made.

13. The manufacturer must have installed the necessary suitable pyrometers to enable the inspector to check at any time the temperature of the annealing operations.

14. The upper portion of the case after the last drawing operation will be annealed at a temperature of from 400 to 450 deg. C. In the annealings between drawings the temperature will in no case exceed 650 deg. C.



Diaphragm FIG. 1

Cartridge Case for 3-In. Field Gun, Models of 1902, 1904 and 1905

OPERATION 1. CUPPING

Transformation—Fig. 2-B. Machine Used—Waterbury-Farrel 450-ton hydraulic press, Fig. 3. Number of Operators per Machine—Two. Punches and Punch Holders—Punch and die, Fig. 9. Pressure Required—40 tons. Lubricant—Drawing and tapering compound, 2 lb. New Era No. 4 to 1 gal. water. Production—4200 in 8 hr. Note—Brass disk: Maximum diameter, 5.805 in.; minimum, 5.800 in.; maximum thickness, 0.313 in.; minimum, 0.308 in.; weight, 2.544 lb.; Fig. 2-A.

OPERATION 2. WASH AND ANNEAL

Number of Operators—Three. Description of Operation—Wash in plain hot water; heat in furnace to 1300 deg. F. for 1 hr. Apparatus and Equipment Used—Tank of hot water, annealing furnace, truck and tray, Fig. 4. Production—5200 in 8 hr.

OPERATION 3. PICKLE AND WASH

Number of Operators—Two. Description of Operation—Dipped in a solution of 6 parts water to 1 of vitriol, then washed in plain hot water. Apparatus and Equipment Used—Dipping baskets and tanks, Fig. 5. Production—4300 per 8 hr.

The various operations on the different sizes of cases are practically alike, the main difference being a few more draws on the gun cases than on those for the howitzers. The punches, dies and gages are all of the same general form, only the dimensions being suited to the several sizes of cases. For this reason detailed descriptions of the operations on all the cartridge cases are unnecessary, since one set of detailed operations will serve as a general guide for all the others.

A detailed drawing of a 3-in. field-gun cartridge case for models of 1902, 1904 and 1905 is given in Fig. 1. It shows not only the case itself, but also the position of the primer and diaphragm, together with details of the two types of diaphragms for use with and without night

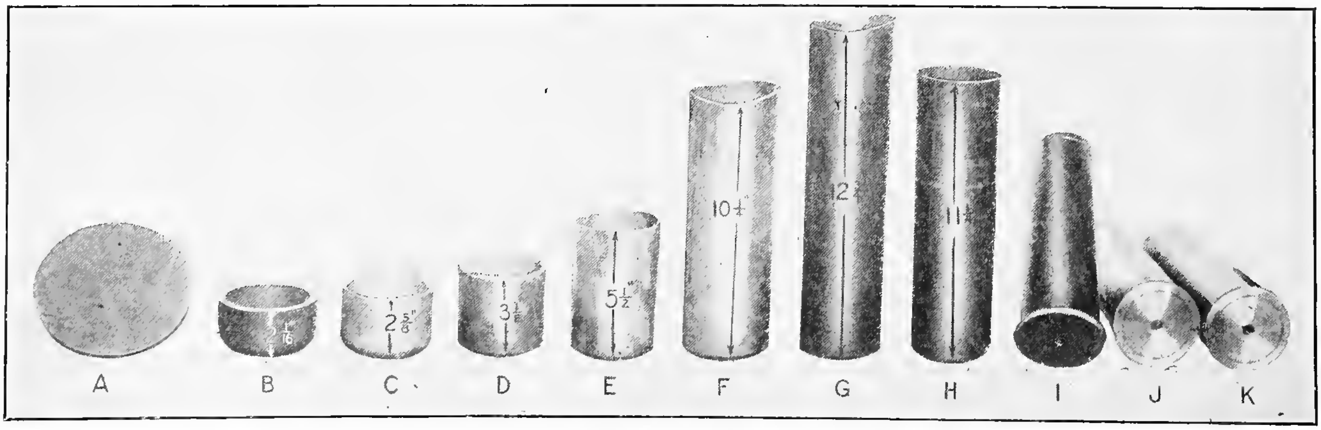
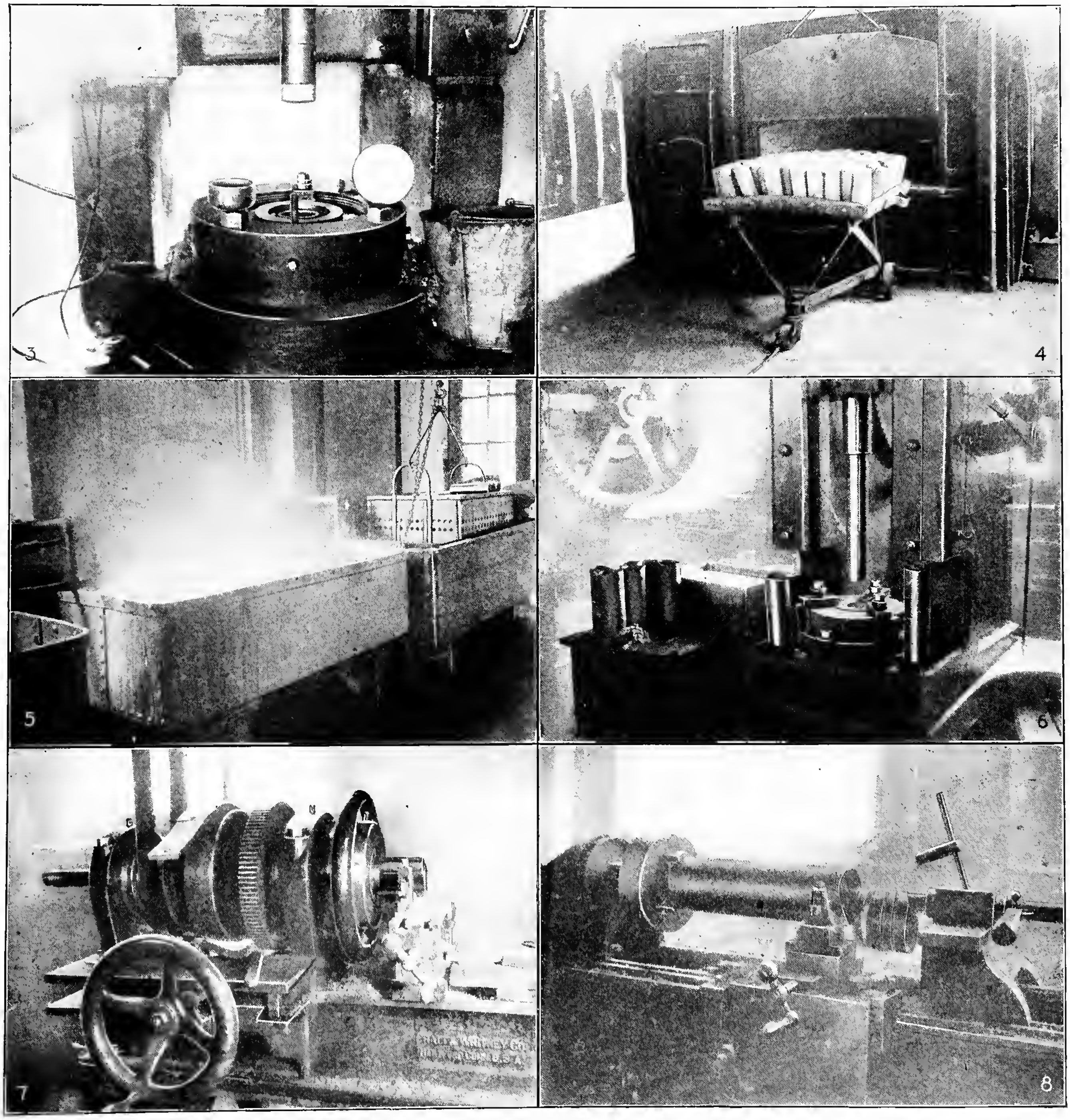


FIG. 2. STEPS IN THE EVOLUTION OF A 3-IN. CARTRIDGE CASE

tracers. The various steps in the evolution of this case are as follows:

1 Cupping
2 Wash and anneal
3 Pickle and wash
4 First draw
5 Wash and anneal
6 Pickle and wash
7 Second draw
8 Wash and anneal
9 Pickle and wash
10 Third draw
11 Wash and anneal
12 Pickle and wash
13 Fourth draw
14 Trim
15 Wash and anneal
16 Pickle and wash
17 Fifth draw
18 Trim
19 Wash for heading
20 Heading
21 Punch primer hole
21-A Drill primer hole and rough head
22 Broach
22-A Burr out
23 Point anneal
24 Taper
25 Finish head
26 Stamp
27 Finish trim
28 Inspect

The principal operations are illustrated in Fig. 2. The first step after the blanking of the disk is the cupping, shown in Fig. 3. The operator dips the disk into the bucket of drawing compound, places it in the die and trips the press, forcing the cup down through the die into a receptacle beneath. The details of the punch and die for this cupping operation may be seen in Fig. 9.



FIGS. 3 TO 8. VARIOUS OPERATIONS ON FIELD-GUN CARTRIDGE CASES

Fig. 3—Cupping. Fig. 4—Annealing. Fig. 5—Pickling and washing. Fig. 6—Drawing. Fig. 7—First trimming. Fig. 8—Second trimming

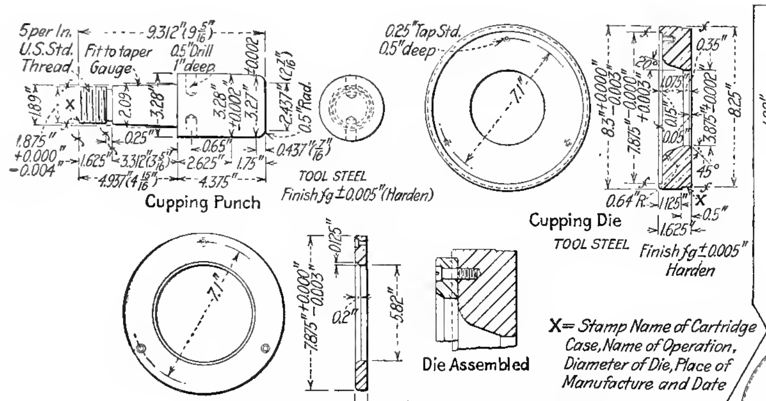


FIG. 9
OPERATION 1

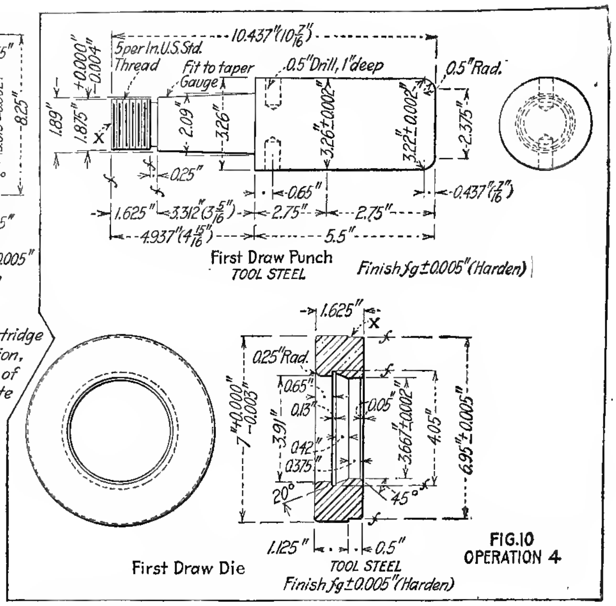


FIG. 10
OPERATION 4

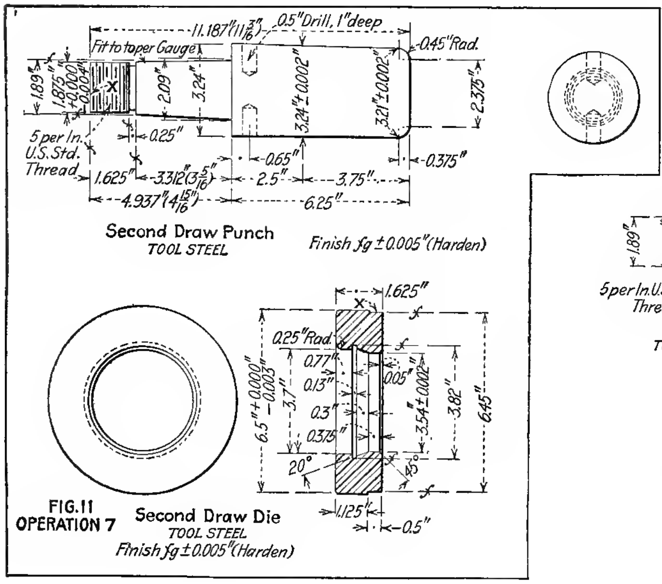


FIG. 11
OPERATION 7

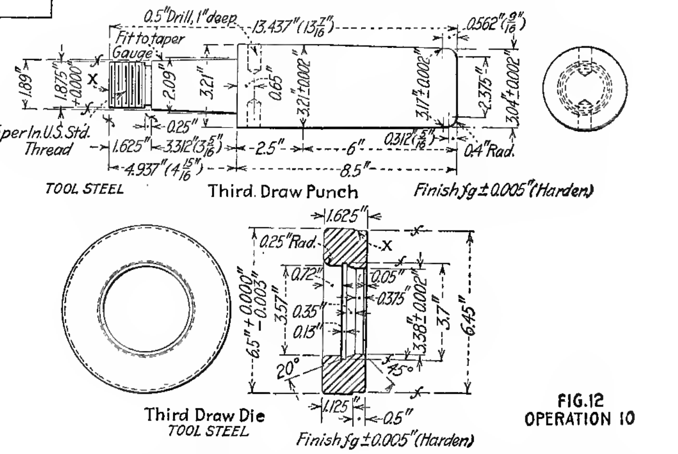


FIG. 12
OPERATION 10

OPERATION 4. FIRST DRAW

Transformation—Fig. 2-C. Machine Used—Waterbury-Farrel rack press. Number of Operators per Machine—Two. Punches and Punch Holders—Punch and die, Fig. 10. Pressure Required—22 tons. Lubricant—New Era No. 4, 2 lb. to 1 gal. water. Production—4300 per 8 hr.

OPERATION 5. WASH AND ANNEAL

Number of Operators—Three. Description of Operation—Same as before. Production—5600 per 8 hr.

OPERATION 6. PICKLE AND WASH

Number of Operators—Two. Description of Operation—Same as before. Production—3500 per 8 hr.

OPERATION 7. SECOND DRAW

Transformation—Fig. 2-D. Number of Operators per Machine—Two. Punches and Punch Holders—Punch and die, Fig. 11. Pressure Required—9 tons. Production—3700 per 8 hr.

OPERATION 8. WASH AND ANNEAL

Number of Operators—Three. Production—6000 per 8 hr.

OPERATION 9. PICKLE AND WASH

Number of Operators—Two. Production—3300 per 8 hr.

OPERATION 10. THIRD DRAW

Transformation—Fig. 2-E. Machine Used—Waterbury-Farrel rack press. Number of Operators per Machine—Two.

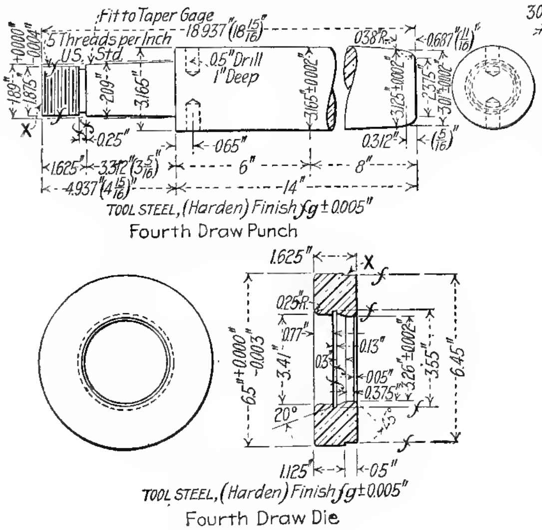


FIG. 13
OPERATION 13

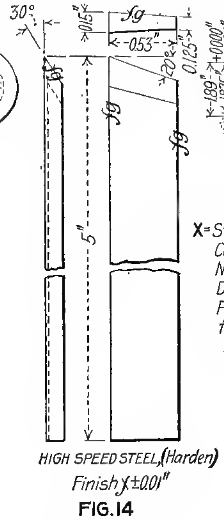


FIG. 14
OPERATION 14

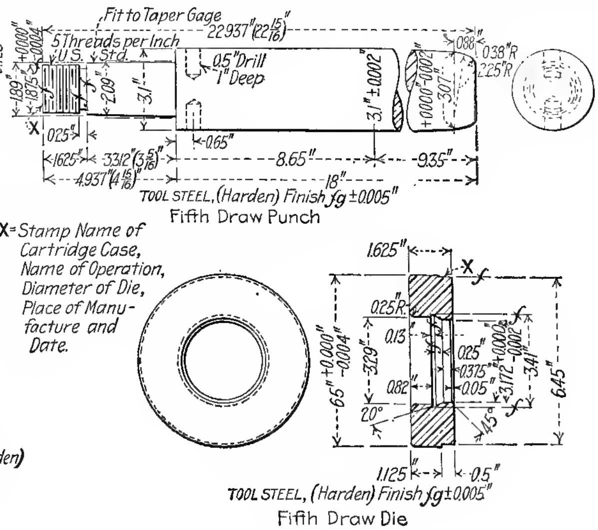


FIG. 15
OPERATION 17

Punches and Punch Holders—Punch and die, Fig. 12. Pressure Required—7 tons. Production—3400 per 8 hr.

OPERATION 11. WASH AND ANNEAL

Description of Operation—Heat to 1300 deg. F. for 50 min. Production—3400 per 8 hr.

OPERATION 12. PICKLE AND WASH

Production—2400 per 8 hr.

OPERATION 13. FOURTH DRAW

Transformation—Fig. 2-F. Machine Used—Rack press, Fig. 6. Number of Operators per Machine—Two. Punches and Punch Holders—Punch and die, Fig. 13. Pressure Required—7 tons. Production—2400 per 8 hr.

OPERATION 14. TRIM

Machine Used—Pratt & Whitney, Fig. 7. Number of Operators per Machine—One. Cutting Tools—Cutoff tool, Fig. 14. Production—1200 per 8 hr. Note—Trim off 20 per cent.

OPERATION 15. WASH AND ANNEAL

Number of Operators—Three. Description of Operation—Heat to 1300 deg. F. for 50 min. Production—3600 per 8 hr.

OPERATION 16. PICKLE AND WASH

Production—1700 per 8 hr.

OPERATION 17. FIFTH DRAW

Transformation—Fig. 2-G. Machine Used—Hydraulic or rack press. Number of Operators per Machine—Two. Punches and Punch Holders—Punch and die, Fig. 15. Pressure Required—3 tons. Production—1900 per 8 hr.

OPERATION 18. TRIM

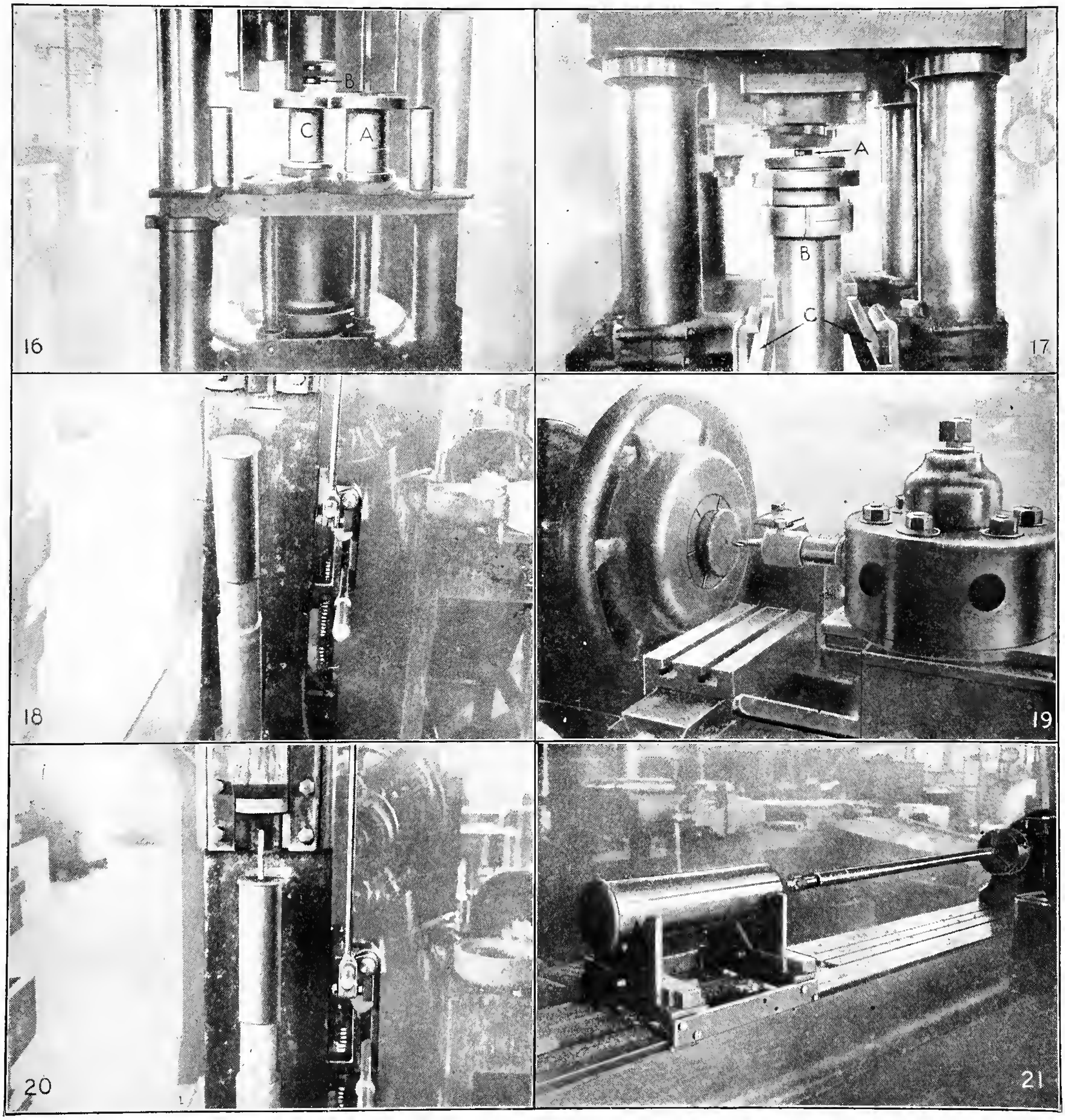
Transformation—Fig. 2-H. Machine Used—Lathe, Fig. 8. Number of Operators per Machine—One. Work-Holding Devices—Three-jaw universal lathe chuck. Cutting Tools—Cutoff tool, Fig. 14. Cut Data—420 r.p.m. Production—1350 per 8 hr.

OPERATION 19. WASH FOR HEADING

Description of Operation—Wash in solution of 25 lb. 6-B washing compound to 75 gal. water. Production—3500 per 8 hr.

OPERATION 20. HEADING

Transformation—Fig. 2-I, minus primer hole. Machine Used—1000-ton hydraulic press, Fig. 16. Number of Operators per



FIGS. 16 TO 21. VARIOUS PRESS AND MACHINING OPERATIONS

Fig. 16, Heading the small-size cases. Fig. 17—Heading large cases. Fig. 18—Punching primer hole. Fig. 19—Drilling and roughing head. Fig. 20—Sizing primer hole. Fig. 21—Burring primer hole

Machine—One. Punches and Punch Holders—Punch, Fig. 22. Dies and Die Holders—Die, Fig. 23. Pressure Required—600 tons. Gages—Snap gage, diameter of head, Fig. 45, operation 25; thickness of head, micrometer gage, Fig. 24. Production—800 per 8 hr.

OPERATION 21. PUNCH PRIMER HOLE

Transformation—Fig. 2-I. Machine Used—Small press, Fig. 18. Number of Operators per Machine—One. Punch and Die—Fig. 25. Production—2800 per 8 hr.

OPERATION 21-A. DRILL PRIMER HOLE AND ROUGH HEAD

Machine Used—Potter & Johnston turret lathe, Fig. 19. Cutting Tools—Tool for turning under head, Fig. 26; drill, reamer. Cut Data—270 r.p.m. Production—800 per 8 hr. Note—This is only done when punch press is not available.

OPERATION 22. BROACH

Machine Used—Fig. 20. Number of Operators per Machine—One. Tool Used—Sizing drift or broach, Fig. 27. Special Fixtures—Fig. 28. Production—2800 per 8 hr.

OPERATION 22-A. BURR OUT

Machine Used—Fig. 21. Number of Operators per Machine—One. Cutting Tools—Burring tool, Fig. 29. Cut Data—Tool runs 750 r.p.m. Special Fixtures—Fig. 30.

OPERATION 23. POINT ANNEAL

Number of Operators—One. Description of Operation—A case is placed as shown in the machine, Fig. 31, the gas jets being so regulated as to heat the case a low red on the open end with the heat gradually lessening toward the head; the holding spindle revolves about 20 r.p.m., and a case will heat in about 1 min. Production—1200 per 8 hr.

The cups are next washed in plain hot water to remove the soapy drawing solution and are then annealed. This is done by placing the cups in trays, as shown in Fig. 4, and pushing the loaded trays into a furnace. Here they are heated to about 1300 deg. F. for an hour; then the tray is pulled out onto the truck and run out into the open air. The tray shown is filled with fourth-draw cases, but the method of procedure is the same in the other annealing operations.

After annealing, the cups are pickled to remove the scale and are then washed in hot water. The pickling is done as shown in Fig. 5. The parts to be pickled are placed in a large basket, as shown at the right, and immersed in the solution. When the scale has all been cut, the basket is raised and run along to the hot-water tank at the left. After washing, the work is ready for the first draw, the punches and dies for which are illustrated in Fig. 10.

The washing, annealing, pickling and washing follow each drawing operation with but slight variations and

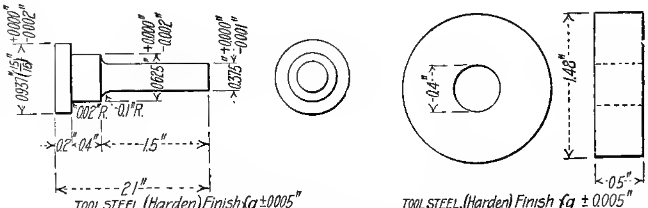


FIG. 25
OPERATION 21

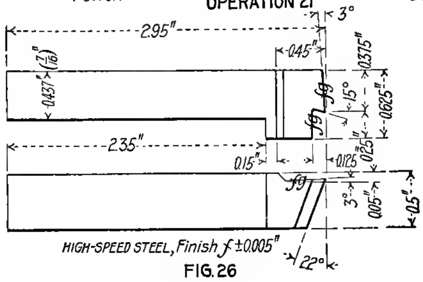


FIG. 26
OPERATION 21A

need not be further described. Details of the punches and dies for the second draw are given in Fig. 11. Figs. 12 and 13 show those for the third and fourth draw. The latter is also illustrated in Fig. 6. Here a tank for the drawing solution is shown just at the left of the press. The operator dips his work into this tank before he places it in the die. After the fourth draw the case is trimmed as shown in Fig. 7, about 20 per cent. of it being removed.

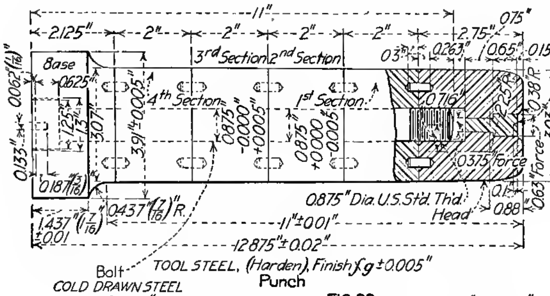


FIG. 22

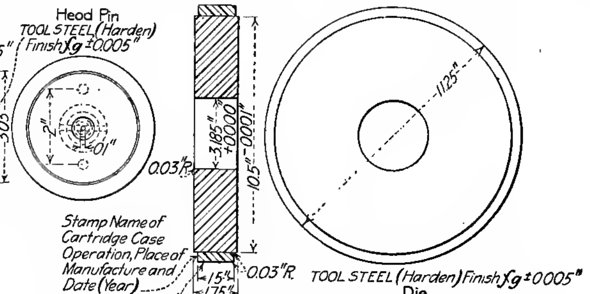


FIG. 23

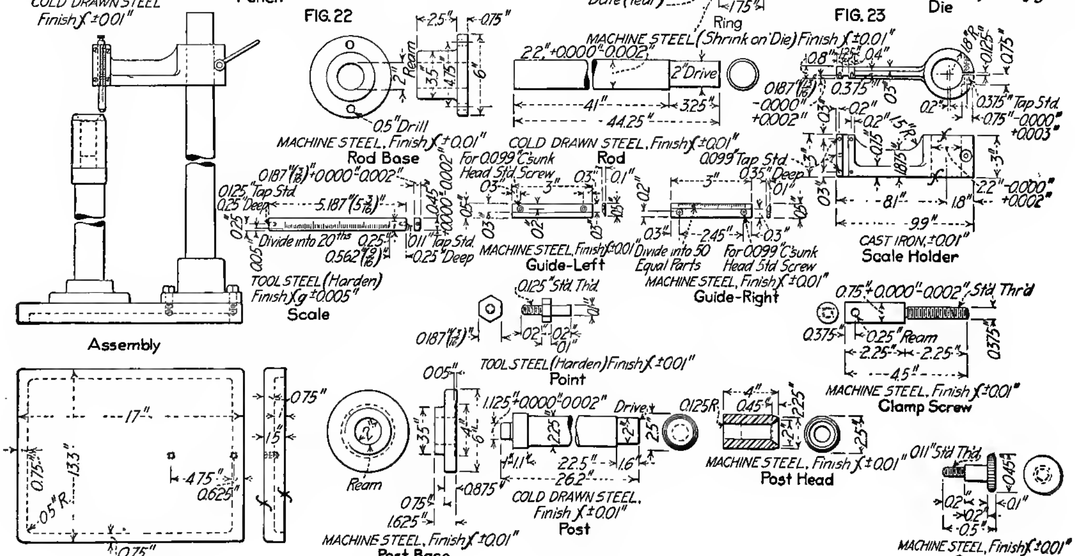


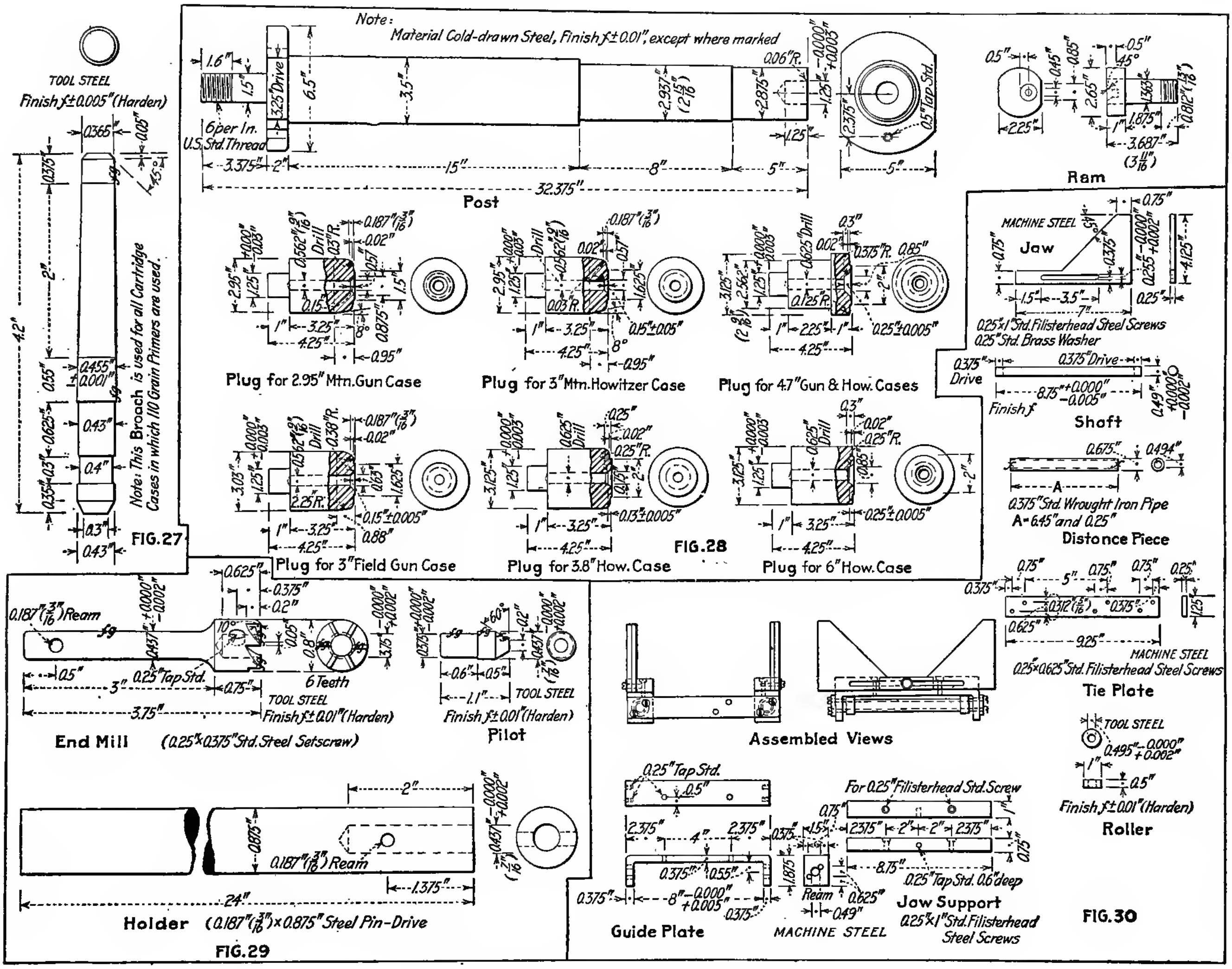
FIG. 24
OPERATION 20

The fifth-draw punches and dies are illustrated in Fig. 15, and the trimming operation, which immediately follows, is shown in Fig. 8. After the case is trimmed, it is washed in a special solution; then it is headed in a hydraulic press, as shown in Fig. 16. Two dies are used in this press, so that the work is practically continuous. A case is placed in one die, as at *A*, while the heading punch *B* is descending on the one at *C*. The die at *C* is then pulled back and the one at *A* pushed into its place, and so on. Details of the die are given in Fig. 23.

A press, Fig. 17, is fitted differently for heading and is used principally on the larger sizes. The case is held in the die at *A*. The die is held in a carrier *B*, which slides on the rails *C* and is run in or out by means of a small hydraulic cylinder and piston at the back.

Primer holes are punched in the small press, Fig. 18. The die is carried in a post hinged at the bottom so that the work and the die may be swung in or out under the punch. Details of the punch and die are given in Fig. 25.

Ordinarily, all primer holes in this type of case are punched; but where no press is available, the hole is drilled and the head roughed off in a turret lathe, as shown in Fig. 19. An ordinary twist drill and a turning tool, Fig. 26, are used. Following either the punching or drilling of the primer hole, a broach or drift is forced through as shown in Fig. 20, to size the hole accurately. The fixture used is made like that for the punching operation, and the drift is shown in Fig. 27. Burring of the primer hole is done from the inside on a small lathe fitted as shown in Fig. 21. The burring tool, detailed in Fig. 29, is carried on the end of a long rod chucked as shown. The case is placed on an adjustable carrier that slides along the lathe bed. The adjustment of the V's allows the fixture to be used for all sizes of cases. Details are given in Fig. 30.



NOTE: FIG. 27, 28 OPERATION 22. FIG. 29, 30 OPERATION 22*a*.

Point annealing of the cases is done in special machines, Figs. 31 and 32. The case to be annealed is placed on the revolving table, and the gas jets play on it in such a way as to heat the mouth end to a good red heat. This heating gradually lessens toward the head of the case, so that the case is left hard on the head end, but increasingly soft toward the mouth, so that as the case is forced into the tapering die, as shown in Fig. 33, the head end does not buckle under the pressure and the case is tapered toward the open end. The tapering die is illustrated in Fig. 37. The heads are finished in a semi-automatic, Fig. 34. In this machine the head is faced, chamfered, the paint groove cut and the primer hole reamed and counterbored. The tools used are given in detail in Figs. 38, 39, 40, 41, 42 and 43. The gages are given in Figs. 24, 44 and 45.

Following the finishing of the head, it is stamped in a hydraulic press, Fig. 35, details of the fixture being given in Fig. 46. The final trimming to exact length is done in a specially fitted turret lathe, Fig. 36. The head is held in a turret chuck *A* and pressed to the revolving tool *B* on the spindle. This chuck and tool are shown in detail in Figs. 47 and 48 respectively. Inspection follows, some of the gages for this purpose being shown in Figs. 50, 51 and 52.

OPERATION 24. TAPERING

Machine Used—Punch press, Fig. 33. Number of Operators per Machine—One. Dies and Die Holders—Die, Fig. 37. Pressure Required—12 tons. Production—1800 per 8 hr.

OPERATION 25. FINISH HEAD

Transformation—Fig. 25. Machine Used—Potter & Johnston automatic, Fig. 34. Number of Machines per Operator—Two. Cutting Tools—Circular form tool, Fig. 38; facing tool, Fig. 39; chamfering tool, Fig. 40; grooving tool, Fig. 41; reamer, Fig. 42; counterbore, Fig. 43. Cut Data—250 r.p.m. Gages—Primer-hole gage, Fig. 44; diameter under head, Fig. 45; primer-hole counterbore, Fig. 44; thickness of head, Figs. 24 and 44; diameter of head, Fig. 45. Production—500 per 8 hr.

OPERATION 26. STAMP

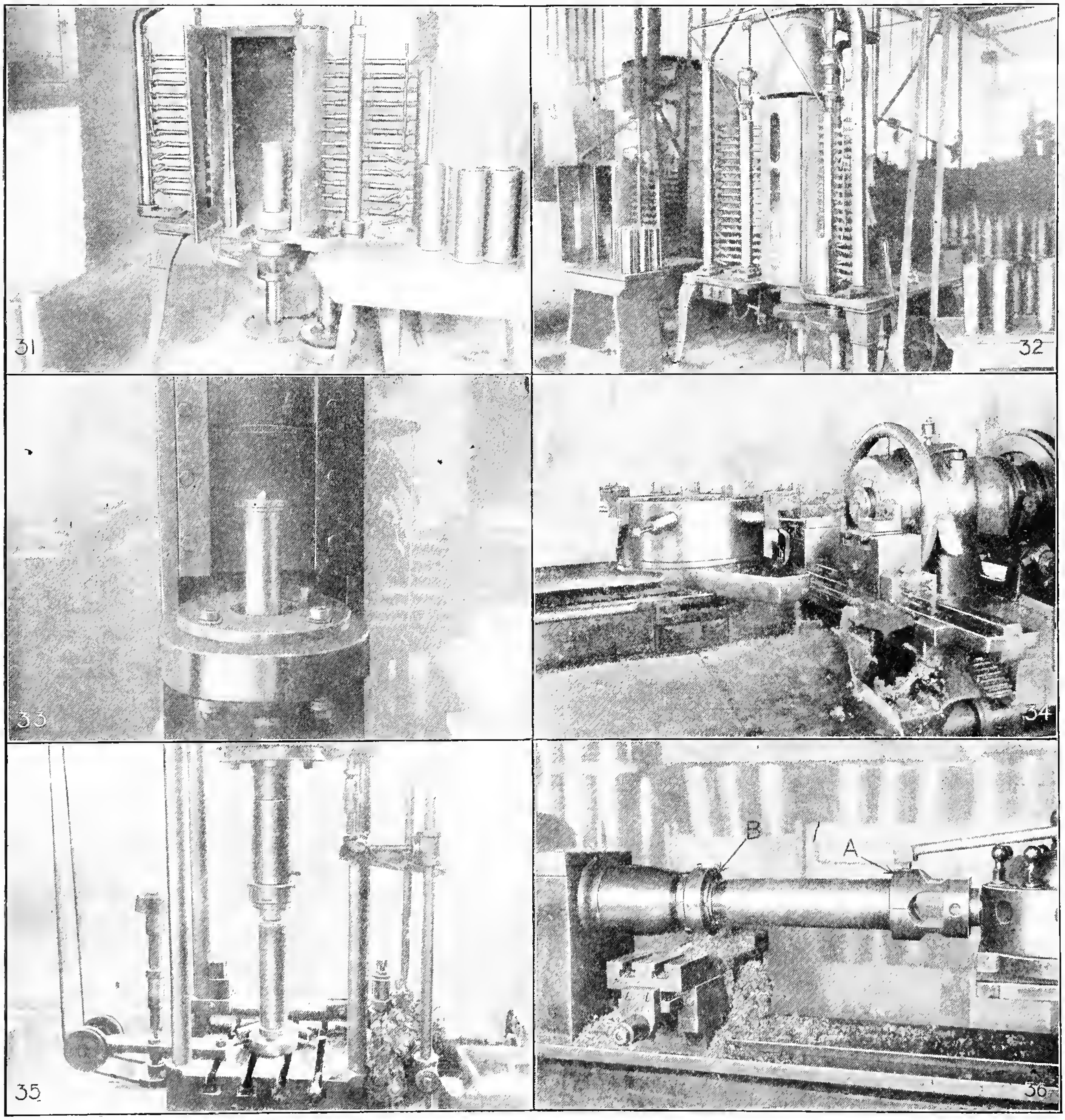
Transformation—Fig. 2-K. Machine Used—30-ton hydraulic press, Fig. 35. Number of Operators per Machine—One. Stamp—See Fig. 1. Pressure Required—13 tons. Special Fixtures—Fig. 46. Production—2500 per 8 hr.

OPERATION 27. FINISH TRIM

Machine Used—Turret lathe, Fig. 36. Number of Operators per Machine—One. Work-Holding Devices—Special chuck, Fig. 47. Tool-Holding Devices—Fixture (tool holder), Fig. 48. Cutting Tools—Inside chamfering, Fig. 48; outside chamfering, Fig. 48; facing, Fig. 48. Cut Data—950 r.p.m. Gages—Length, Fig. 49. Production—1800 per 8 hr.

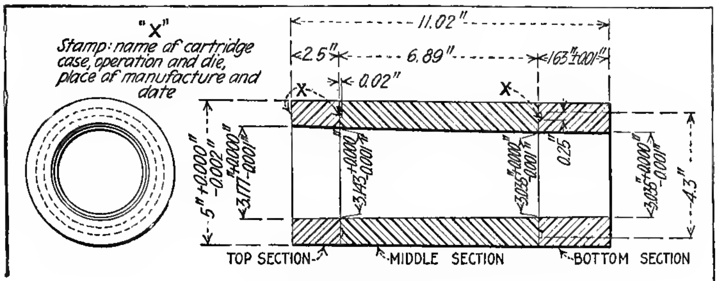
OPERATION 28. INSPECTION

Apparatus and Equipment Used—Fig. 50. · Gages—Mouth plug gage, Fig. 51; primer-hole gage, Fig. 44; primer-hole counterbore, Fig. 44; thickness of head, Fig. 44; diameter of head, Fig. 45; diameter under head, Fig. 45; length gage, Fig. 52; cylinder gage, Fig. 50.

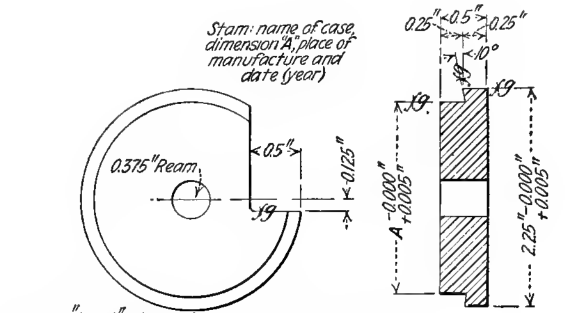


FIGS. 31 TO 36. ANNEALING, PRESSING AND MACHINING WORK

Fig. 31—Point-annealing machine open. Fig. 32—Same machine closed. Fig. 33—Tapering the case. Fig. 34—Machining the head. Fig. 35—Stamping the head. Fig. 36—Finish trimming

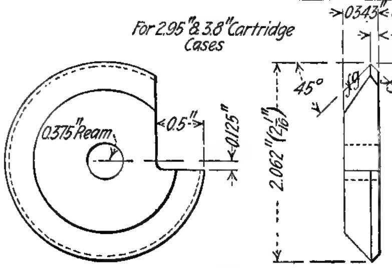


Tapering Die
TOOL STEEL
Finish ƒg ±0.005" Harden
FIG. 37, OP. 24

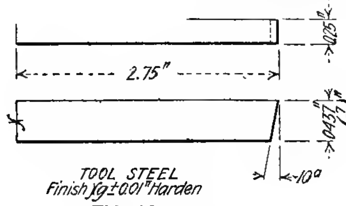


A = 1.980" for 2.95" Mt. Gun Cart Case
A = 2.007" for 3" Field Gun Mod. 1902, '04 1905 Cart Case
A = 1.987" for 3" Mt. How Mod. 1907, 11 & 4.7" How.
A = 2.007" for 3.8" How Mod. 1908, Cart Case
A = 2.002" for 4.7" Gun Mod 1906 Cart Case
A = 1.997" for 6" How Mod 1906, '08 Cart Case

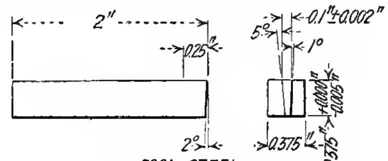
HIGH SPEED STEEL
Finish ƒ ±0.01" Harden
FIG. 38



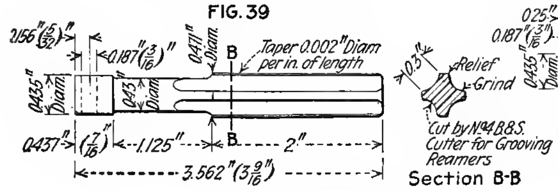
HIGH SPEED STEEL
Finish ƒ ±0.01" Harden
FIG. 39



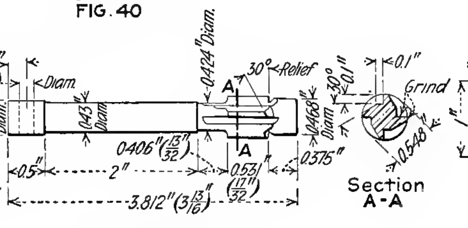
TOOL STEEL
Finish ƒg ±0.01" Harden
FIG. 40



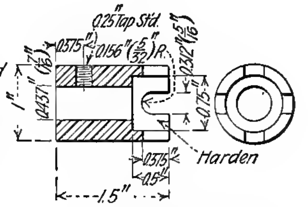
TOOL STEEL
Finish ƒ ±0.01" Harden
FIG. 41



Reamer
TOOL STEEL
(Finish, Harden)
FIG. 42



Counterbore
TOOL STEEL
(Finish, Harden)
OPERATION 25



Counterbore Stop
TOOL STEEL
Finish
0.25" x 0.25" Headless Std. Set Screw
FIG 43

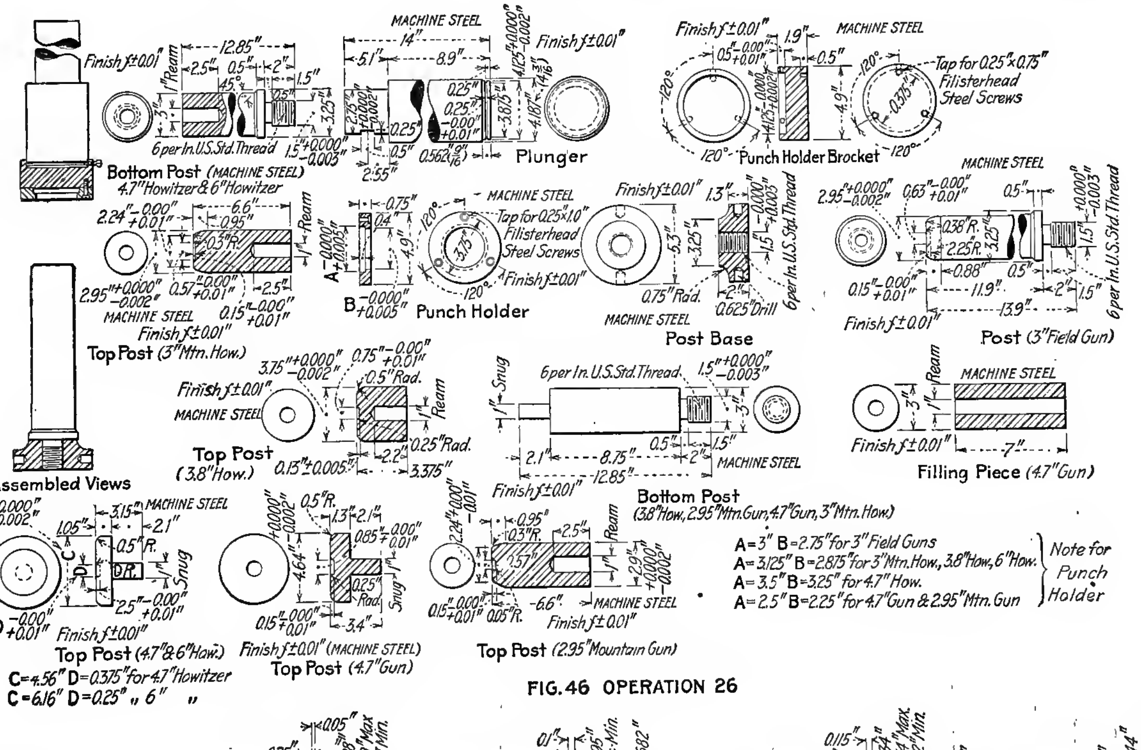
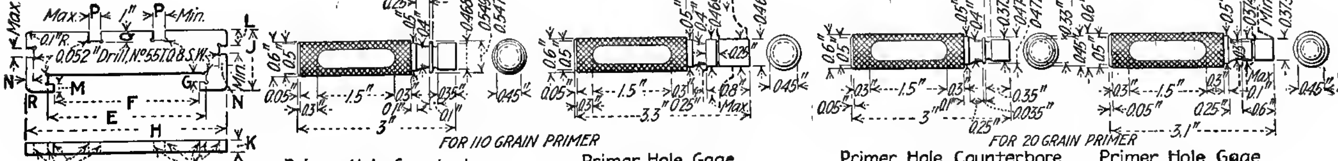


FIG. 46 OPERATION 26



Head Gage
FORGED STEEL No. 3
(Harden & Grind)

Primer Hole Counterbore Gage
FORGED STEEL No. 3
Finish, H. & G.

Primer Hole Gage
FORGED STEEL No. 3
Finish, H. & G.

Primer Hole Counterbore Gage
FORGED STEEL No. 3
Finish, H. & G.

Primer Hole Gage
FORGED STEEL No. 3
Finish H. & G.

FIG. 44, OP. 25

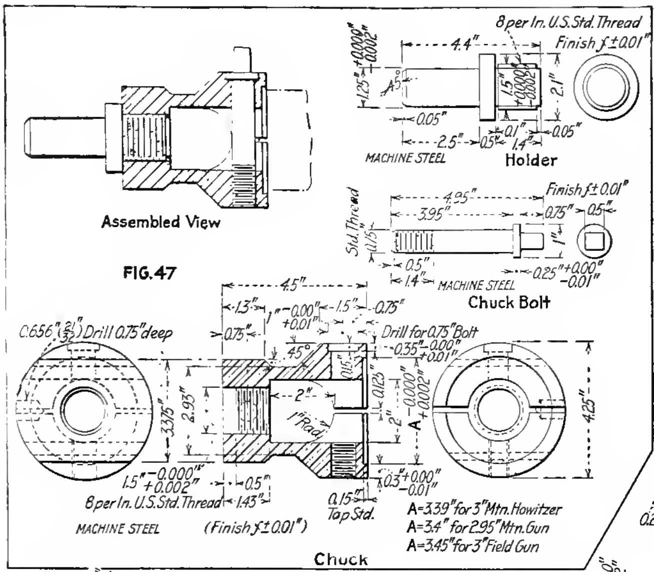
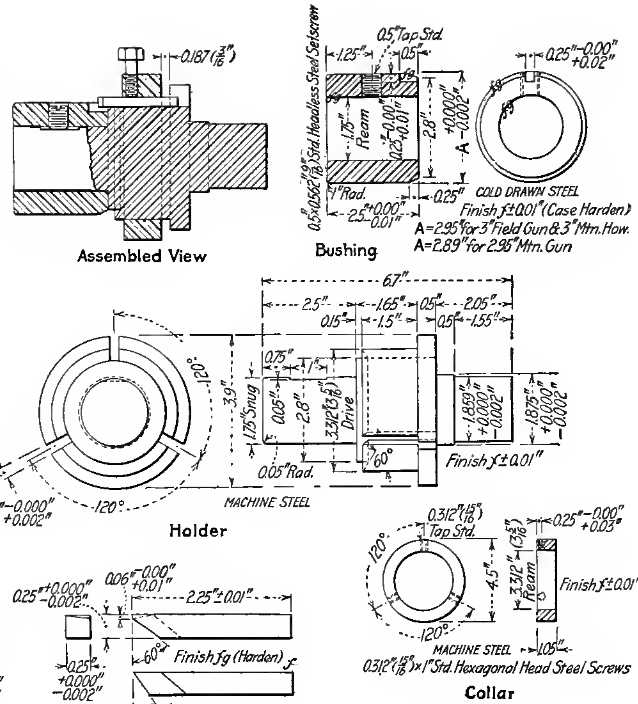


FIG. 47



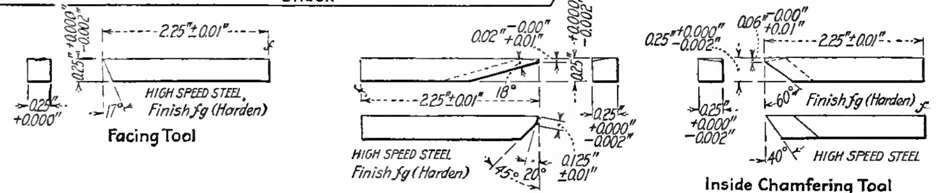


FIG. 48

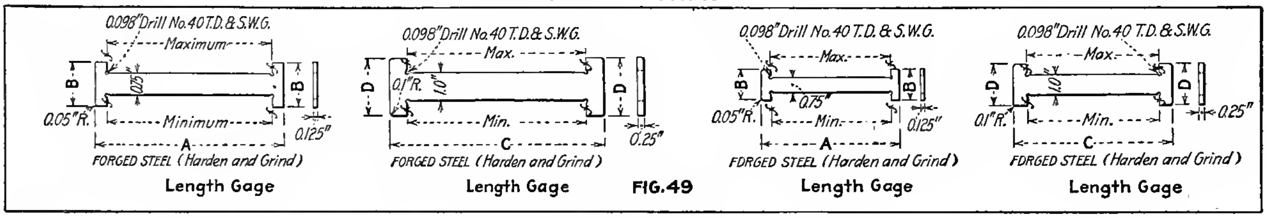


FIG. 49

OPERATION 27

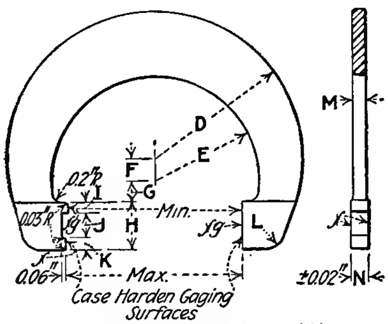


FIG. 45, OP. 25

The Diaphragm and the Tube for Tracers

The diaphragm is made of sheet brass; the operations are:

Operation
1 Blank and form
2 Pierce for tracer tube

The punches and dies used for the first operation are shown in Fig. 54, but the second is a simple piercing operation.

The tube is set into the diaphragm when a night tracer is used. It is also made of sheet brass and is evolved in the following order:

Operation
1 Blank and first draw
2 Anneal
3 Pickle and wash

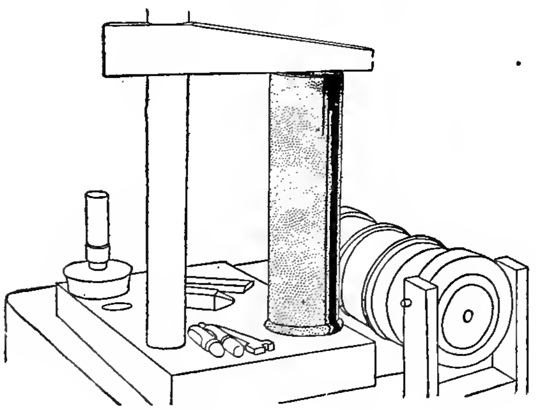


FIG. 50

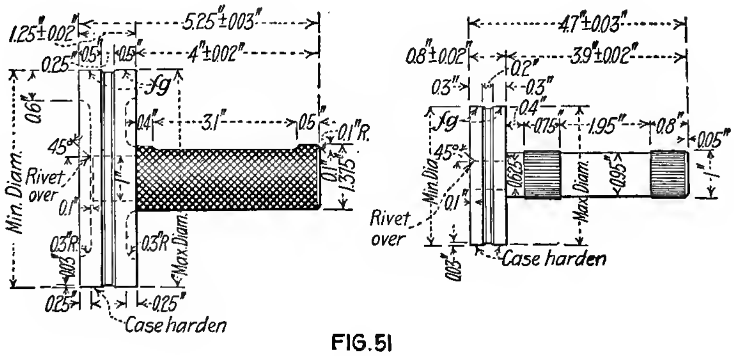


FIG. 51

4 Second draw
5 Anneal
6 Pickle and wash
7 Third draw
8 Anneal
9 Pickle and wash
10 Fourth draw
11 Anneal
12 Pickle and wash
13 Fifth draw
14 Trim
15 Start flange
16 Assemble
17 Solder

The blanking and first drawing die may be seen in Fig. 56. The second- and third-draw dies are shown in Fig. 57 and those for the fourth and fifth draw in Fig. 58. The trimming and flanging fixtures are illustrated in Fig. 59.

OPERATION 7. THIRD DRAW

Transformation—Fig. 57. Punch and Die—Fig. 57. Production—4000 per 8 hr.

OPERATION 8. ANNEAL

Production—10,000 per 8 hr.

OPERATION 10. FOURTH DRAW

Transformation—Fig. 58. Punch and Die—Fig. 58. Production—4000 per 8 hr.

OPERATION 11. ANNEAL

Production—10,000 per 8 hr.

OPERATION 12. PICKLE AND WASH

Production—10,000 per 8 hr.

OPERATION 13. FIFTH DRAW

Transformation—Fig. 58. Punch and Die—Fig. 58. Production—4000 per 8 hr.

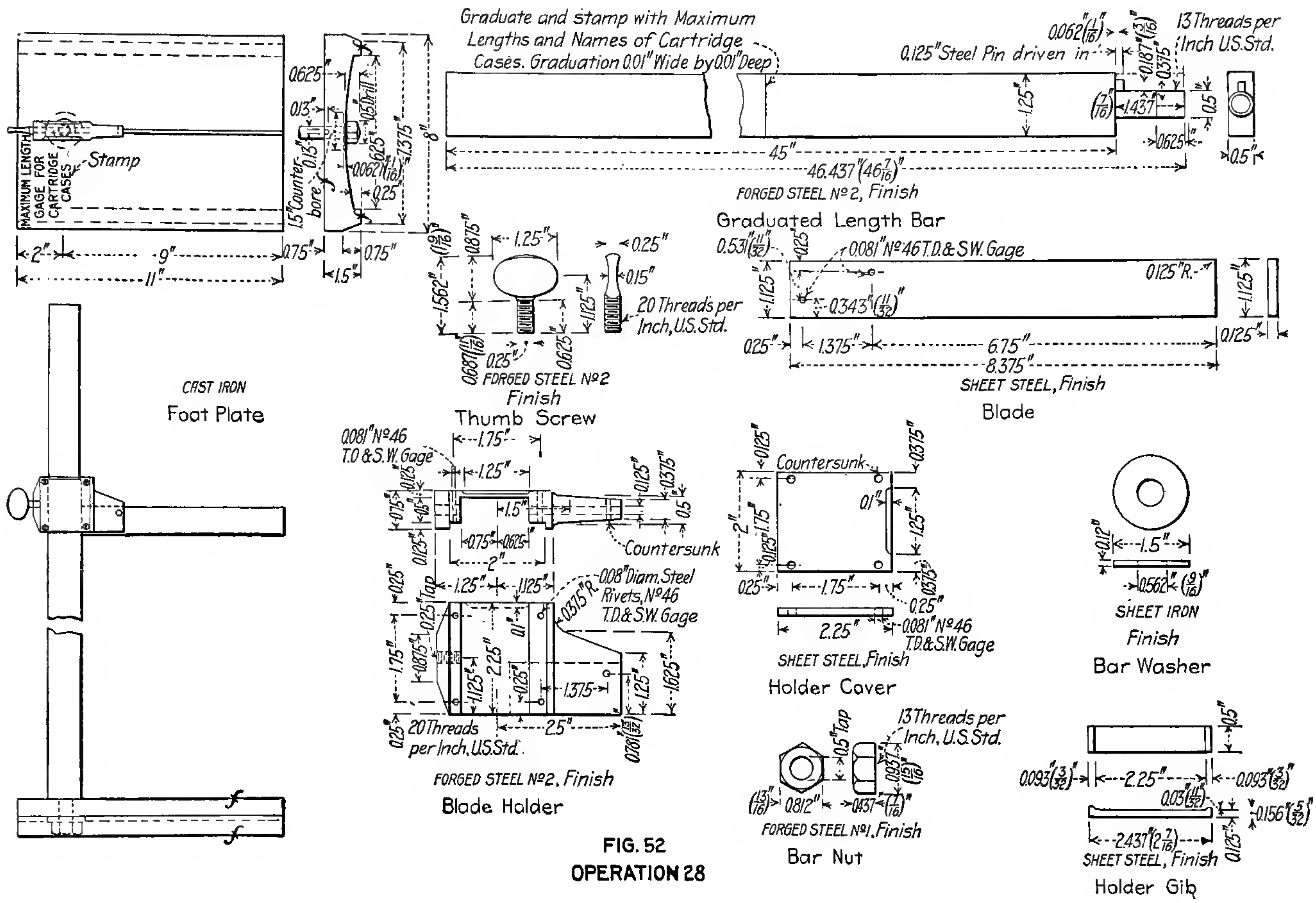


FIG. 52
OPERATION 28

Diaphragm

OPERATION 1. BLANK AND FORM

Punches and Dies—Fig. 54. Production—8000 per 8 hr.

OPERATION 2. PIERCE

Transformation—Fig. 55. Production—8000 per 8 hr. Note—A 1-in. hole is pierced for the tracer tube, with common punch and die.

Tube for Tracer

OPERATION 1. BLANK AND FIRST DRAW

Transformation—Fig. 56. Punch and Die—Fig. 56. Production—8000 per 8 hr.

OPERATION 2. ANNEAL

Production—10,000 per 8 hr.

OPERATION 3. PICKLE AND WASH

Production—10,000 per 8 hr.

OPERATION 4. SECOND DRAW

Transformation—Fig. 57. Punch and Die—Fig. 57. Production—4000 per 8 hr.

OPERATION 5. ANNEAL

Production—10,000 per 8 hr.

OPERATION 6. PICKLE AND ANNEAL

Production—10,000 per 8 hr.

OPERATION 14. TRIM

Machine Used—Small lathe. Special Fixtures—Fig. 59. Production—4000 per 8 hr.

OPERATION 15. START FLANGE

Special Fixtures—Fig. 59. Production—4000 per 3 hr.

OPERATION 16. ASSEMBLE

Production—4000 per 8 hr. Note—Tube is pressed through hole in diaphragm.

OPERATION 17. SOLDER

Production—500 per 8 hr.

Cartridge Case for 3-In. Mountain Howitzer, Models of 1907 and 1911

OPERATION 1. CUPPING

Details of Cartridge Case—Fig. 60. Punch and Die—Fig. 61. Pressure Required—18 tons. Production—4200 per 8 hr. Size of Blank—Maximum diameter, 4.905 in.; minimum diameter, 4.900 in.; maximum thickness, 0.317 in.; minimum thickness, 0.312 in.; weight, 1 lb. 13¾ oz.

SUCCEEDING OPERATIONS

Operation
2 Wash and anneal; production, 5700
3 Pickle and wash; production, 2700

4 First draw; punch and die, Fig. 62; pressure required, 15 tons; production, 4300
5 Wash and anneal; production, 5700
6 Pickle and wash; production, 3600
7 Second draw; punch and die, Fig. 63; pressure, 12 tons; production, 3700
8 Wash and anneal; production, 6000
9 Pickle and wash; production, 2400
10 Third draw; punch and die, Fig. 64; pressure, 7 tons; production, 3400
11 Wash and anneal; production, 3600
12 Pickle and wash; production, 1800
13 Fourth draw; punch and die, Fig. 65; pressure, 5 tons; production, 2400

DIAPHRAGM

Operation
1 Blank and form; punch and die same as for field gun
2 Shear soldering strip; production, 3000
3 Shear, blank and form clip; production, 6000
4 Form soldering strip; production, 1000
5 Solder soldering strip to diaphragm; production, 300
6 Scrape solder from diaphragm; tools, chuck and scraper; production, 1000
7 Cut cords; production, 12,000
8 Tie and paraffin cords; production, 3500
9 Solder cords to soldering strip and clip; production, 500

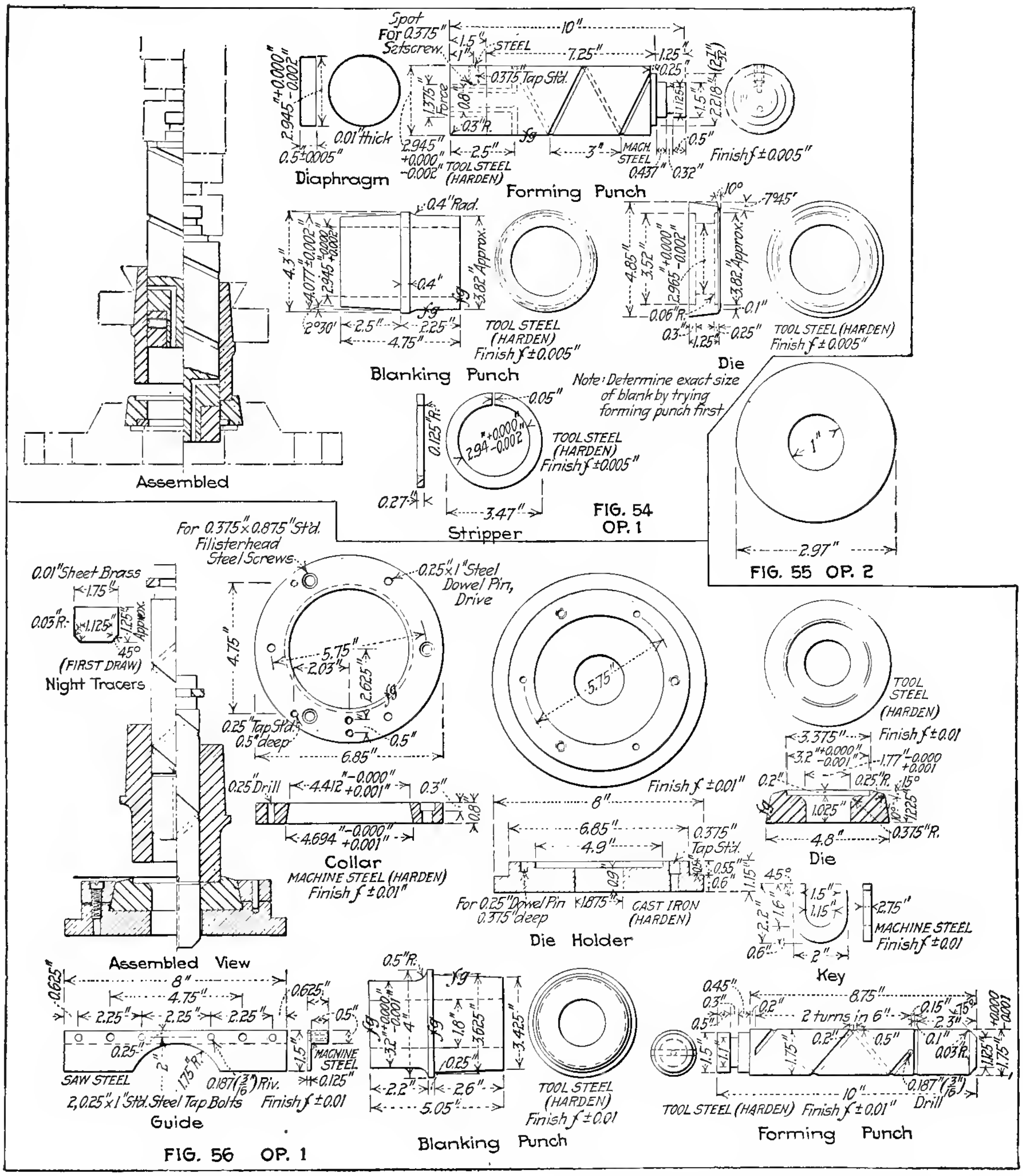


FIG. 54 OP. 1

FIG. 55 OP. 2

FIG. 56 OP. 1

14 Wash and anneal; production, 3800
15 Pickle and wash; production, 2000
16 Fifth draw; punch and die, Fig. 66; pressure, 2 tons; production, 1900
17 Trim; production, 1350
18 Wash for heading; production, 3500
19 Heading; punch and die, Fig. 67; pressure, 600 tons
20 Punch primer hole; production, 2800
20-A Rough head and drill primer hole
21 Broach
22 Burr out
23 Point anneal
24 Tapering; die, Fig. 68; production, 1800
25 Finish head
26 Stamp
27 Finish trim; length gage, Fig. 49
28 Inspection; gages are same as used for field-gun cartridge case except length and cylinder case, Fig. 67

Cartridge Case for 3-In. Gun, 15-Pounder, Model 1898-1902

OPERATION 1. CUPPING

Details of Cartridge Case—Fig. 70. Punch and Die—Fig. 71. Pressure Required—73 tons. Size of Blank—Maximum diameter, 8.505 in.; minimum diameter, 8.500 in.; maximum thickness, 0.469 in.; minimum thickness, 0.459 in.; weight, 8.125 lb.

SUCCEEDING OPERATIONS

Operation
2 Wash and anneal
3 Pickle and wash
4 First draw; punch and die, Fig. 72; pressure required, 47 tons
5 Wash and anneal

6 Pickle and wash
7 Second draw; punch and die, Fig. 73; pressure required, 45 tons
8 Wash and anneal
9 Pickle and wash
10 Third draw; punch and die, Fig. 74; pressure required, 42 tons
11 Wash and anneal
12 Pickle and wash
13 Fourth draw; punch and die, Fig. 75; pressure required, 31 tons
14 Wash and anneal
15 Pickle and wash
16 Fifth draw; punch and die, Fig. 76; pressure required, 26 tons
17 Wash and anneal
18 Pickle and wash
19 Sixth draw; punch and die, Fig. 77; pressure required, 15 tons
34 First point anneal; approximate heat, 1300 deg. F.: 6 min.
35 First tapering; die, Fig. 81; pressure, 45 tons
36 Second point anneal
37 Second tapering; die, Fig. 82; pressure, 45 tons
38 Final trim
39 Finish-turn head
40 Stamp head; pressure required, 15 tons
41 Final anneal
42 Inspect

Cartridge Case for 3-In. Gun, 15-Pounder, Model 1903

OPERATION 1. CUPPING

Details of Cartridge Case—Fig. 83. Punch and Die—Fig. 84. Pressure—60 tons. Disk—Maximum diameter, 9.380 in.;

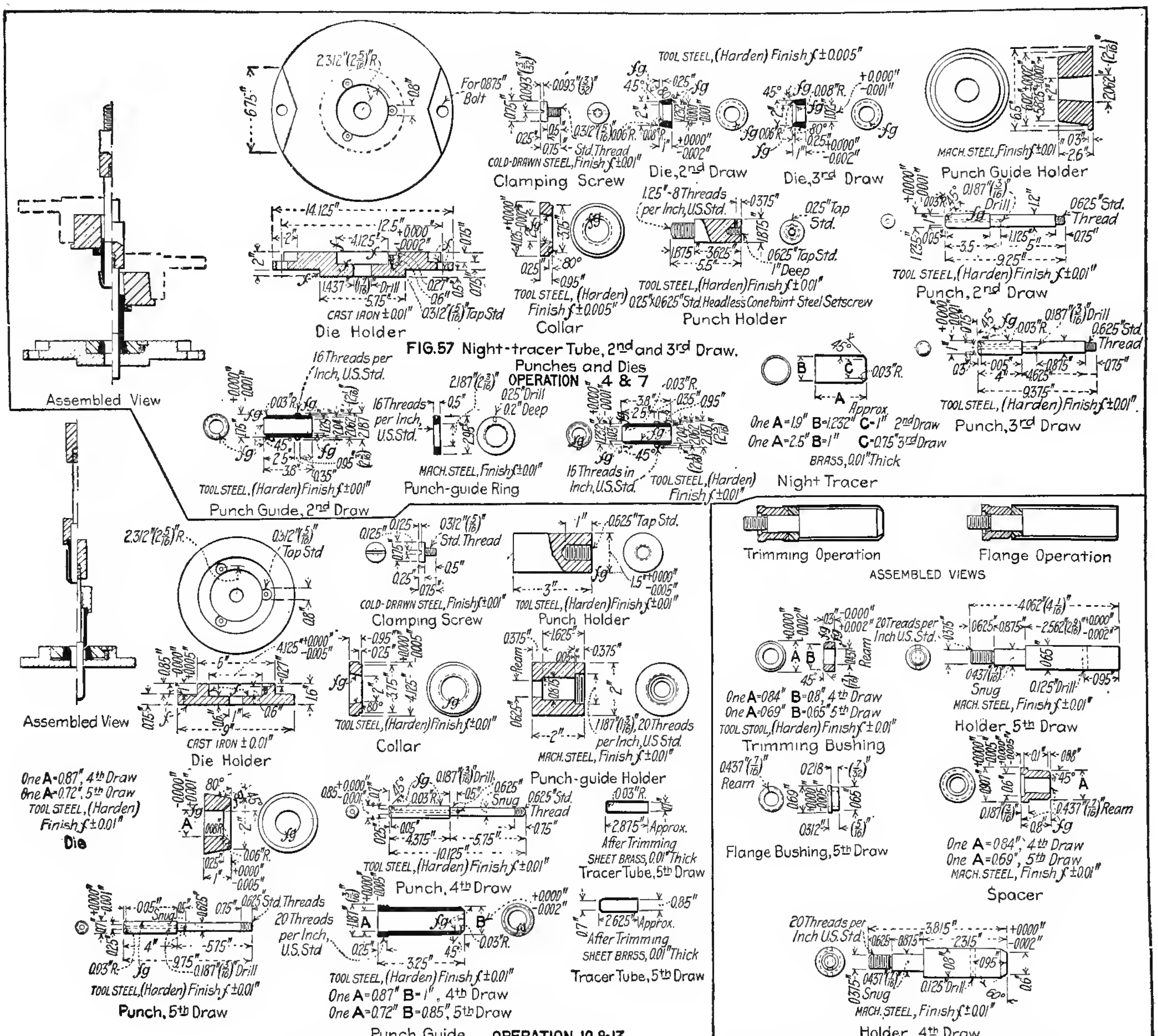


FIG. 57 Night-tracer Tube, 2nd and 3rd Draw. Punches and Dies OPERATION 4 & 7

FIG. 58 4th and 5th Draw OPERATION 10 & 13

FIG. 59 Fixture for Trimming and Flanging OPERATION 14 & 15

20 Sixth-draw trim; trim off 20 per cent.
21 Wash and anneal
22 Pickle and wash
23 Seventh draw; punch and die, Fig. 78; pressure required, 10 tons
24 Seventh-draw trim
25 Wash and anneal
26 Pickle and wash
27 Eighth draw; punch and die. Fig. 79; pressure required, 7 tons
28 Eighth-draw trim
29 Wash for heading
30 Heading; punch and die, Fig. 80; pressure required, 850 tons
31 Rough-turn heads and drill primer hole
32 Broach primer hole
33 Burr out

minimum diameter, 9.375 in.; maximum thickness, 0.438 in.; minimum thickness, 0.428 in.; weight, 9.25 lb.

SUCCEEDING OPERATIONS

Operation
2 Wash and anneal
3 Pickle and wash
4 First draw; punch and die, Fig. 85; pressure required, 45 tons
5 Wash and anneal
6 Pickle and wash
7 Second draw; punch and die, Fig. 86; pressure, 40 tons
8 Wash and anneal
9 Pickle and wash
10 Third draw; punch and die, Fig. 87; pressure, 30 tons
11 Wash and anneal

12 Pickle and wash
13 Fourth draw; punch and die, Fig. 88; pressure, 30 tons
14 Wash and anneal
15 Pickle and wash
16 Fifth draw; punch and die, Fig. 89; pressure, 20 tons
17 Wash and anneal
18 Pickle and wash
19 Sixth draw; punch and die, Fig. 90; pressure required, 10 tons
20 Sixth-draw trim; trim off 20 per cent.
21 Wash and anneal
22 Pickle and wash
23 Seventh draw; punch and die, Fig. 91; pressure required, 8 tons
24 Seventh-draw trim
25 Wash and anneal
26 Pickle and wash
27 Eighth draw; punch and die, Fig. 92; pressure, 5 tons
28 Eighth-draw trim
29 Wash for heading
30 Heading; punch and die, Fig. 93; pressure, 1050 tons
31 Rough-turn head and drill primer hole
32 Broach
33 Burr out
34 First point anneal
35 First taper; die, Fig. 94; pressure, 50 tons
36 Second point anneal
37 Second taper; die, Fig. 95; pressure, 50 tons
38 Final trim
39 Finish-turn head
40 Stamp
41 Final anneal
42 Inspect

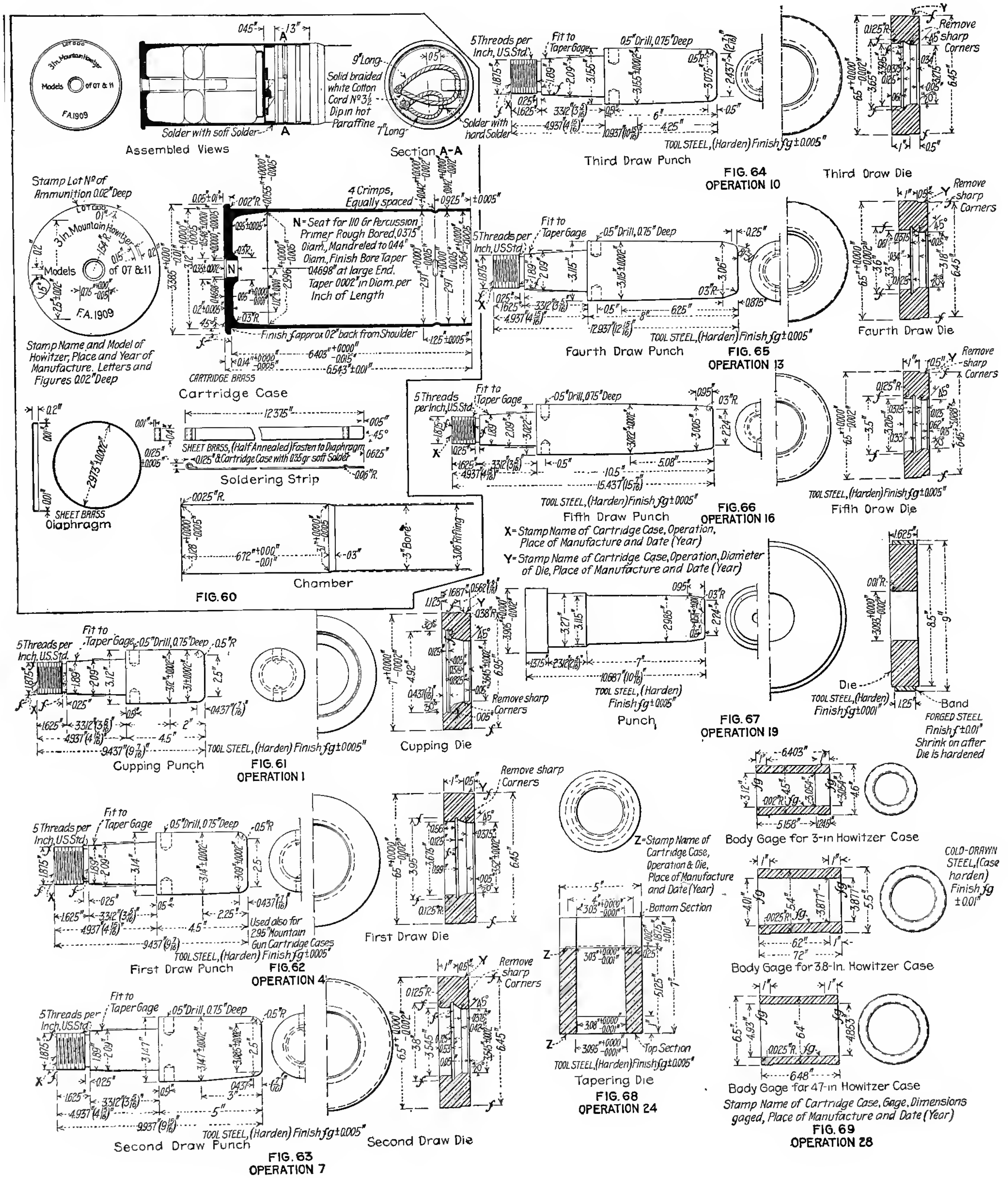


FIG. 60 — Assembled Views; Cartridge Case; Soldering Strip; Diaphragm; Chamber

FIG. 61 OPERATION 1 — Cupping Punch; Cupping Die

FIG. 62 OPERATION 4 — First Draw Punch; First Draw Die

FIG. 63 OPERATION 7 — Second Draw Punch; Second Draw Die

FIG. 64 OPERATION 10 — Third Draw Punch; Third Draw Die

FIG. 65 OPERATION 13 — Fourth Draw Punch; Fourth Draw Die

FIG. 66 OPERATION 16 — Fifth Draw Punch; Fifth Draw Die

X = Stamp Name of Cartridge Case, Operation, Place of Manufacture and Date (Year)

Y = Stamp Name of Cartridge Case, Operation, Diameter of Die, Place of Manufacture and Date (Year)

FIG. 67 OPERATION 19 — Punch; Die

FIG. 68 OPERATION 24 — Tapering Die

FIG. 69 OPERATION 28 — Body Gage for 3-in Howitzer Case; Body Gage for 3.8-In. Howitzer Case; Body Gage for 4.7-in Howitzer Case. Stamp Name of Cartridge Case, Gage, Dimensions gaged, Place of Manufacture and Date (Year)

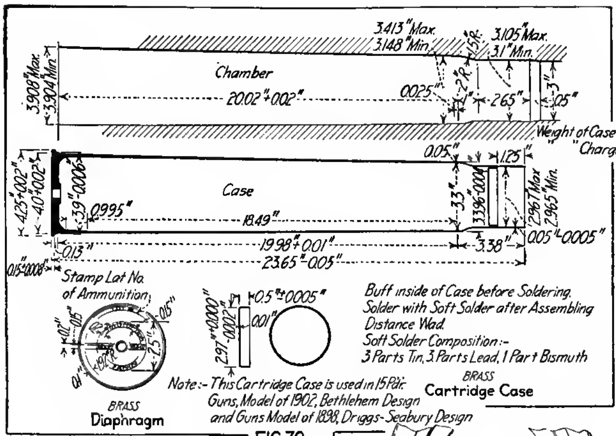


FIG. 70

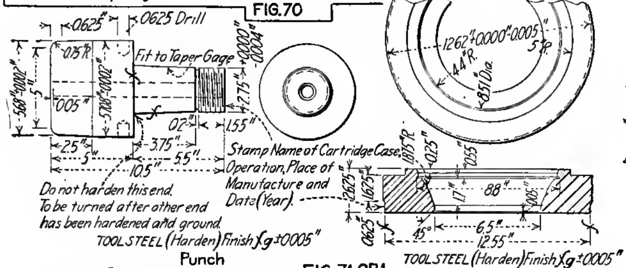


FIG. 71, OP. 1

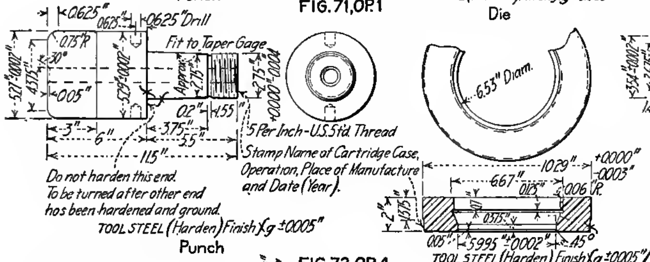


FIG. 72, OP. 4

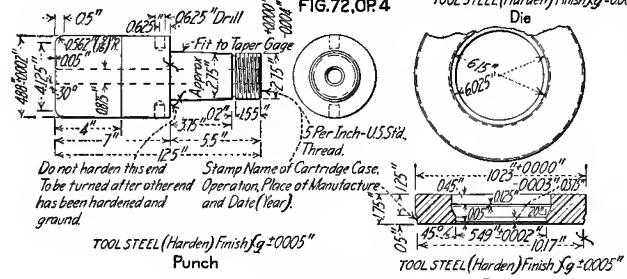


FIG. 73, OP. 7

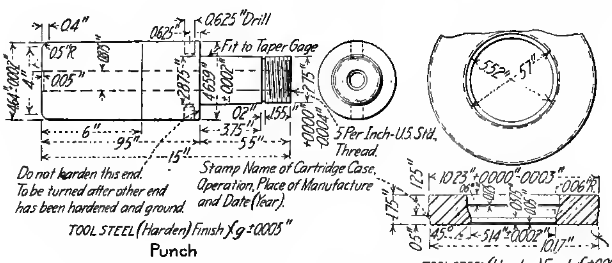


FIG. 74, OP. 10

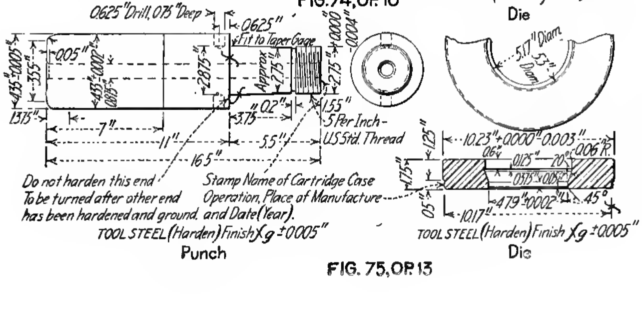


FIG. 75, OP. 13

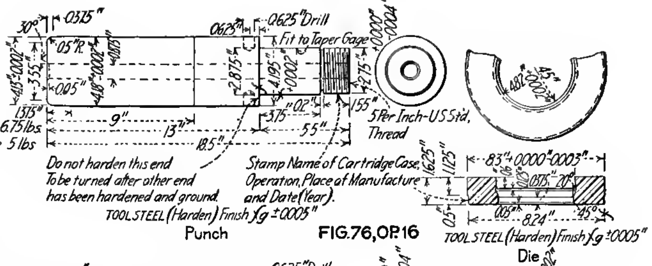


FIG. 76, OP. 16

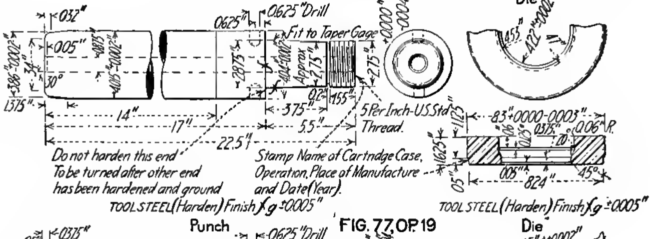


FIG. 77, OP. 19

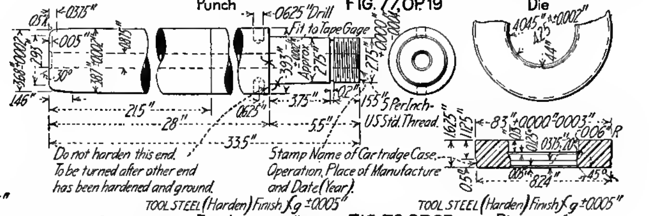


FIG. 78, OP. 23

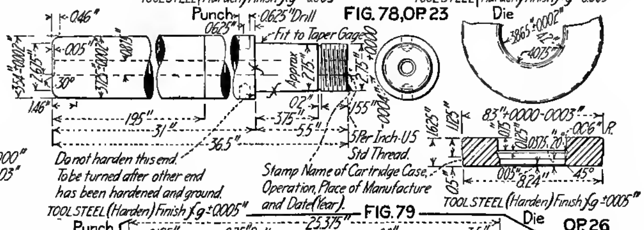


FIG. 79

OP. 26

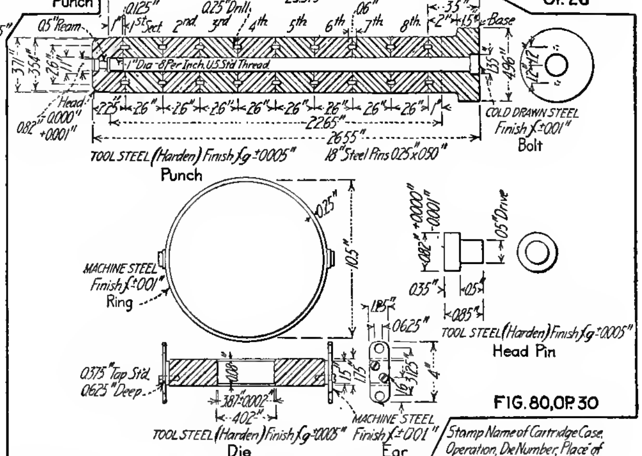


FIG. 80, OP. 30

Stamp Name of Cartridge Case, Operation, Die Number, Place of Manufacture and Date (Year).

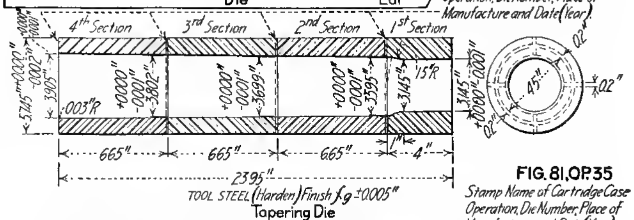


FIG. 81, OP. 35

Stamp Name of Cartridge Case Operation, Die Number, Place of Manufacture, and Date (Year).

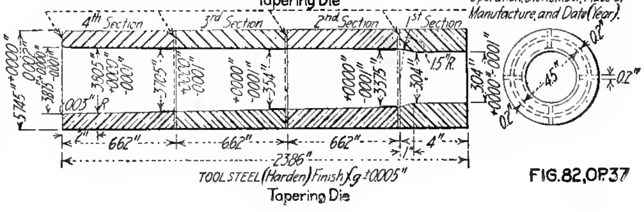


FIG. 82, OP. 37

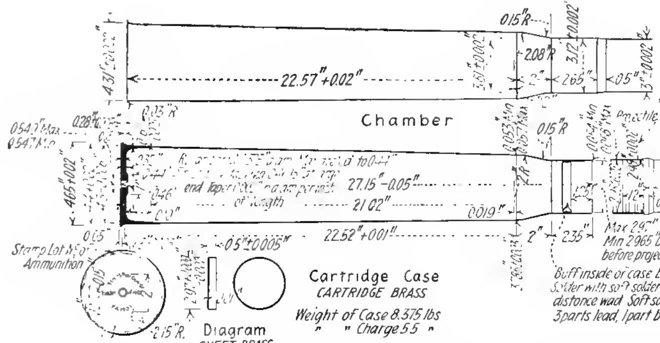


FIG. 83

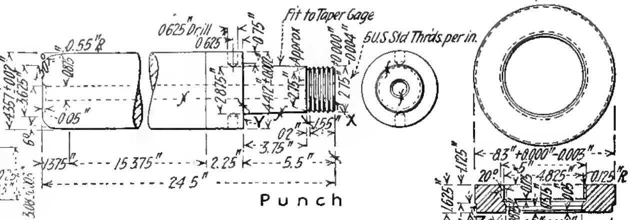


FIG. 90, OP. 19

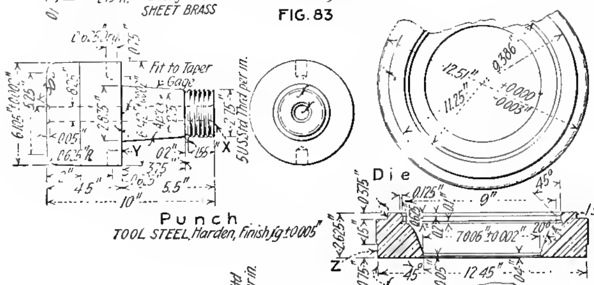


FIG. 84, OP. 1

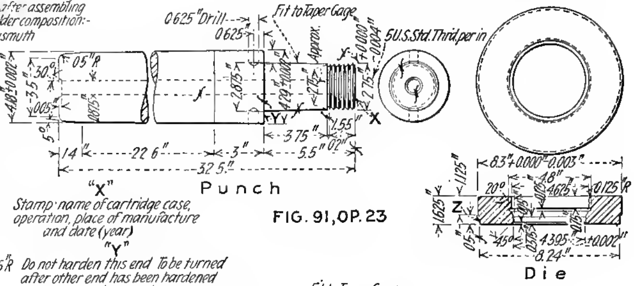


FIG. 91, OP. 23

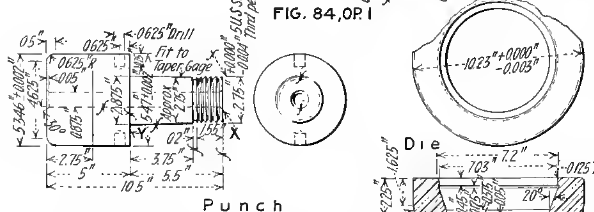


FIG. 85, OP. 4

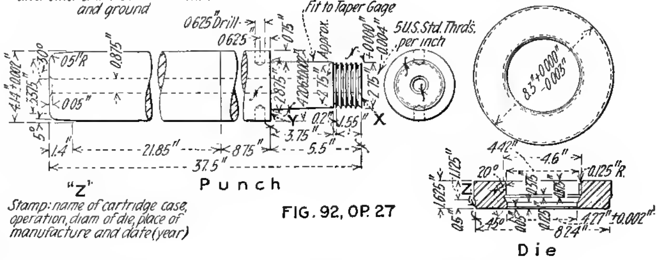


FIG. 92, OP. 27

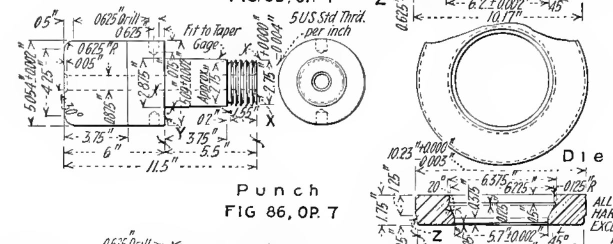


FIG. 86, OP. 7

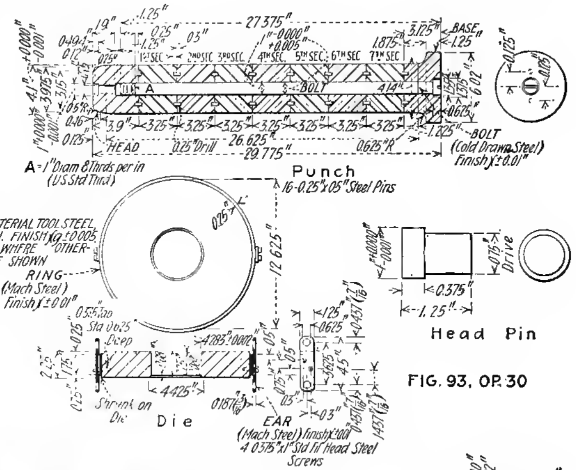


FIG. 93, OP. 30

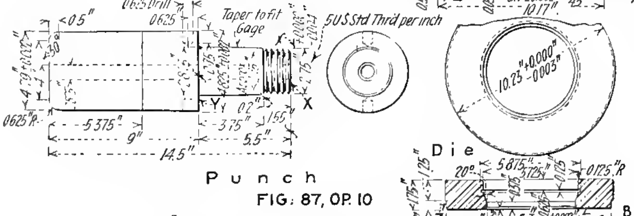


FIG. 87, OP. 10

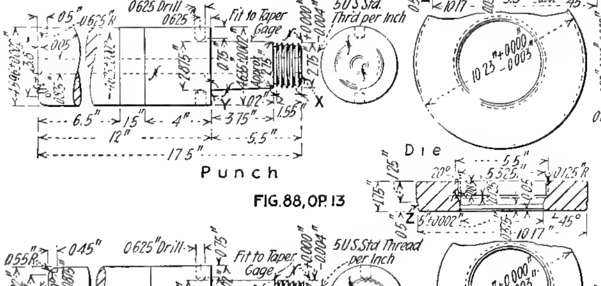


FIG. 88, OP. 13

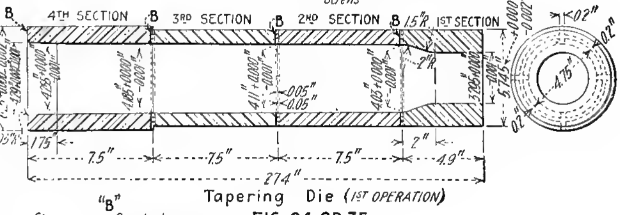


FIG. 94, OP. 35

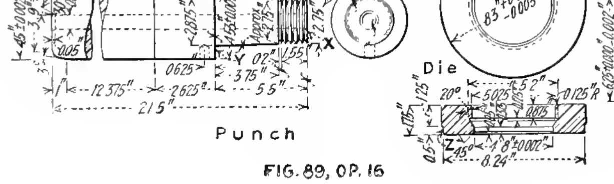


FIG. 89, OP. 16

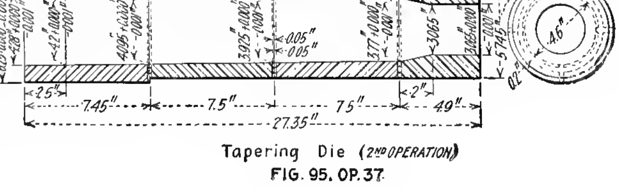


FIG. 95, OP. 37

The operation lists, dimensions, dies and other information on the other cartridge cases up to 6 in. in both the gun and howitzer types are as follows:

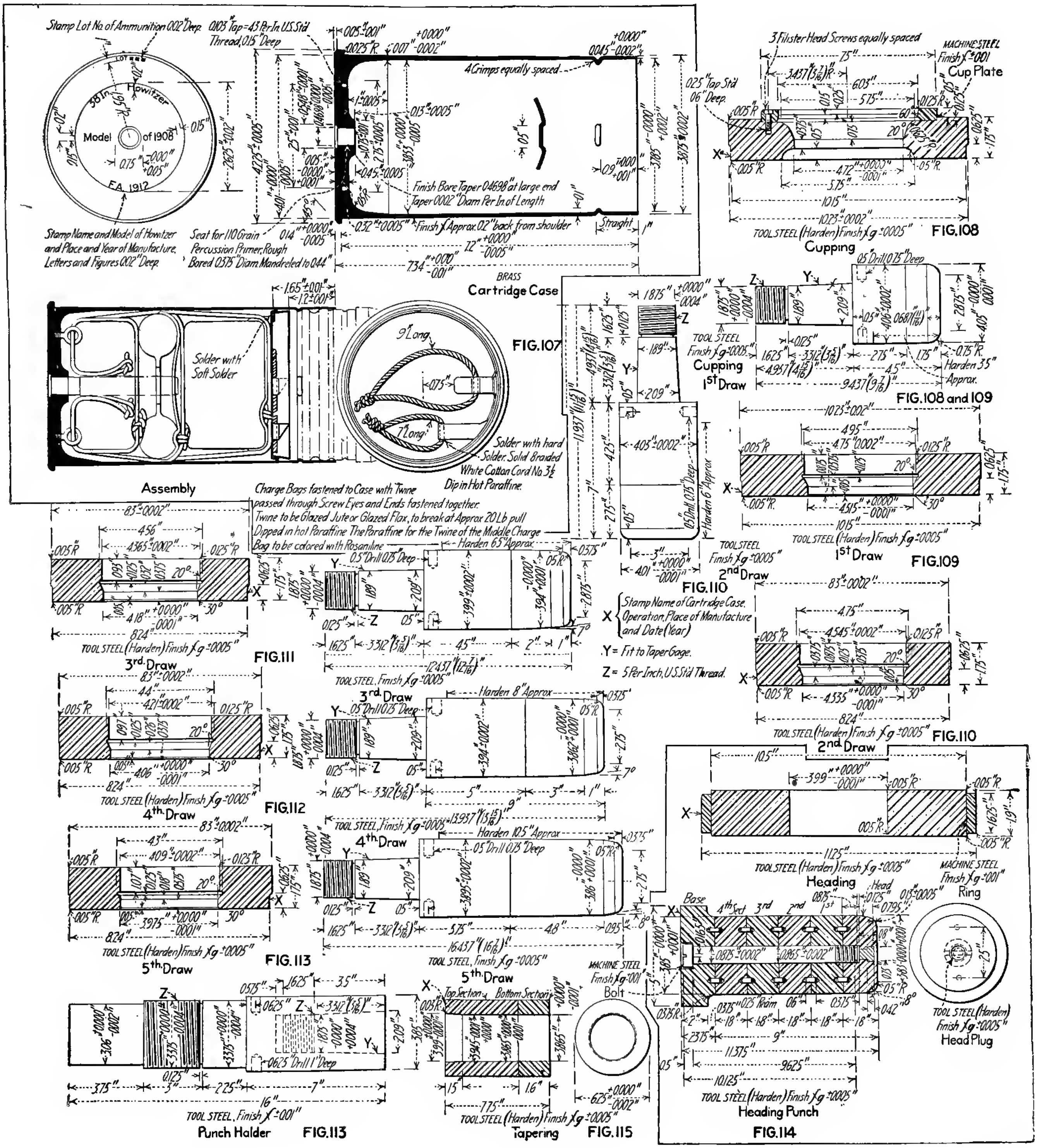
Cartridge Case for 3.8-In. Howitzer, Model 1908

OPERATION 1. CUPPING

Details of Cartridge Case—Fig. 107. Punch and Die—Fig. 108. Pressure Required—50 tons. Dimensions of Disk—Maximum diameter, 6.005 in.; minimum diameter, 6 in.; maximum thickness, 0.431 in.; minimum thickness, 0.421 in.; weight, 3.739 lb.

SUCCEEDING OPERATIONS

Operation
2 Wash and anneal
3 Pickle and wash
4 First draw; punch and die, Fig. 109; pressure required, 30 tons
5 Wash and anneal
6 Pickle and wash
7 Second draw; punch and die, Fig. 110; pressure, 20 tons
8 Wash and anneal
9 Pickle and wash
10 Third draw; punch and die, Fig. 111; pressure, 15 tons
11 Wash and anneal
12 Pickle and wash
13 Fourth draw; punch and die, Fig. 112; pressure, 13 tons
14 Wash and anneal
15 Pickle and wash
16 Fifth draw; punch and die, Fig. 113; pressure, 10 tons
17 Fifth-draw trim
18 Wash for heading
19 Heading; die, Fig. 114; pressure, 1000 tons
20 Rough-turn head and drill primer hole
21 Broach
22 Burr out
23 Point anneal
24 Taper; die, Fig. 115; pressure, 20 tons



25 Finish-turn heads
26 Drill for screw-eyes
27 Tap for screw-eyes
28 Stamp
29 Final trim
30 Inspect

Cartridge Case for 4.7-In. Gun, Model 1906

OPERATION 1. CUPPING

Details of Cartridge Case—Fig. 116. Punch and Die—Fig. 117. Pressure—65 tons. Dimensions of Disk—Maximum diameter, 8.630 in.; minimum diameter, 8.625 in.; maximum thickness, 0.505 in.; minimum thickness, 0.495 in.; weight, 8.987 lb.

SUCCEEDING OPERATIONS

Operation

2 Wash and anneal
3 Pickle and wash
4 First draw; punch and die, Fig. 118; pressure, 60 tons
5 Wash and anneal
6 Pickle and wash
7 Second draw; punch and die, Fig. 119; pressure, 45 tons
8 Wash and anneal
9 Pickle and wash
10 Third draw; punch and die, Fig. 120; pressure, 40 tons
11 Wash and anneal
12 Pickle and wash
13 Fourth draw; punch and die, Fig. 121; pressure, 30 tons
14 Wash and anneal
15 Pickle and wash
16 Fifth draw; punch and die, Fig. 122; pressure, 25 tons
17 Wash and anneal
18 Pickle and wash
19 Sixth draw; punch and die, Fig. 123; pressure, 20 tons
20 Sixth-draw trim; remove 20 per cent.
21 Wash and anneal
22 Pickle and wash
23 Seventh draw; punch and die, Fig. 124; pressure, 15 tons
24 Seventh-draw trim
25 Wash for heading
26 Heading; die, Fig. 125; pressure, 1400 tons
27 Rough-turn head and drill primer hole
28 Broach
29 Burr out
30 Point anneal
31 Taper; die, Fig. 126; pressure, 45 tons
32 Finish-turn head
33 Stamp; pressure, 15 tons
34 Final trim
35 Inspect

Cartridge Case for 4.7-In. Howitzer, Models of 1907, 1908 and 1912

OPERATION 1. CUPPING

Details of Cartridge Case—Fig. 127. Punch and Die—Fig. 128. Pressure—90 tons. Dimensions of Disk—Maximum diameter, 7.105 in.; minimum diameter, 7.100 in.; maximum thickness, 0.465 in.; minimum thickness, 0.455 in.; weight, 6 lb 9 oz.

SUCCEEDING OPERATIONS

Operation

2 Wash and anneal
3 Pickle and wash
4 First draw; punch and die, Fig. 129; pressure, 50 tons
5 Wash and anneal
6 Pickle and wash
7 Second draw; punch and die, Fig. 130; pressure, 45 tons

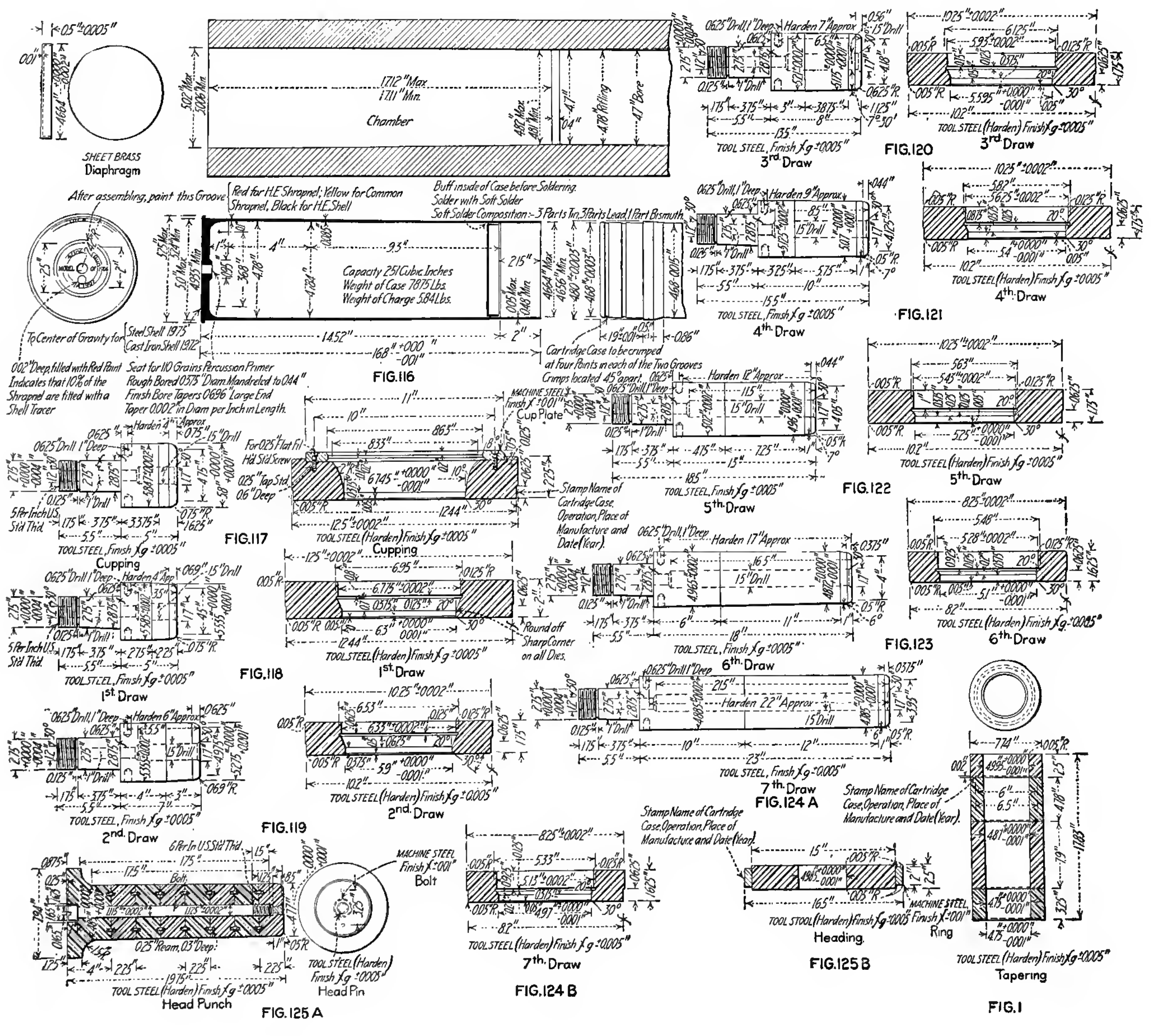
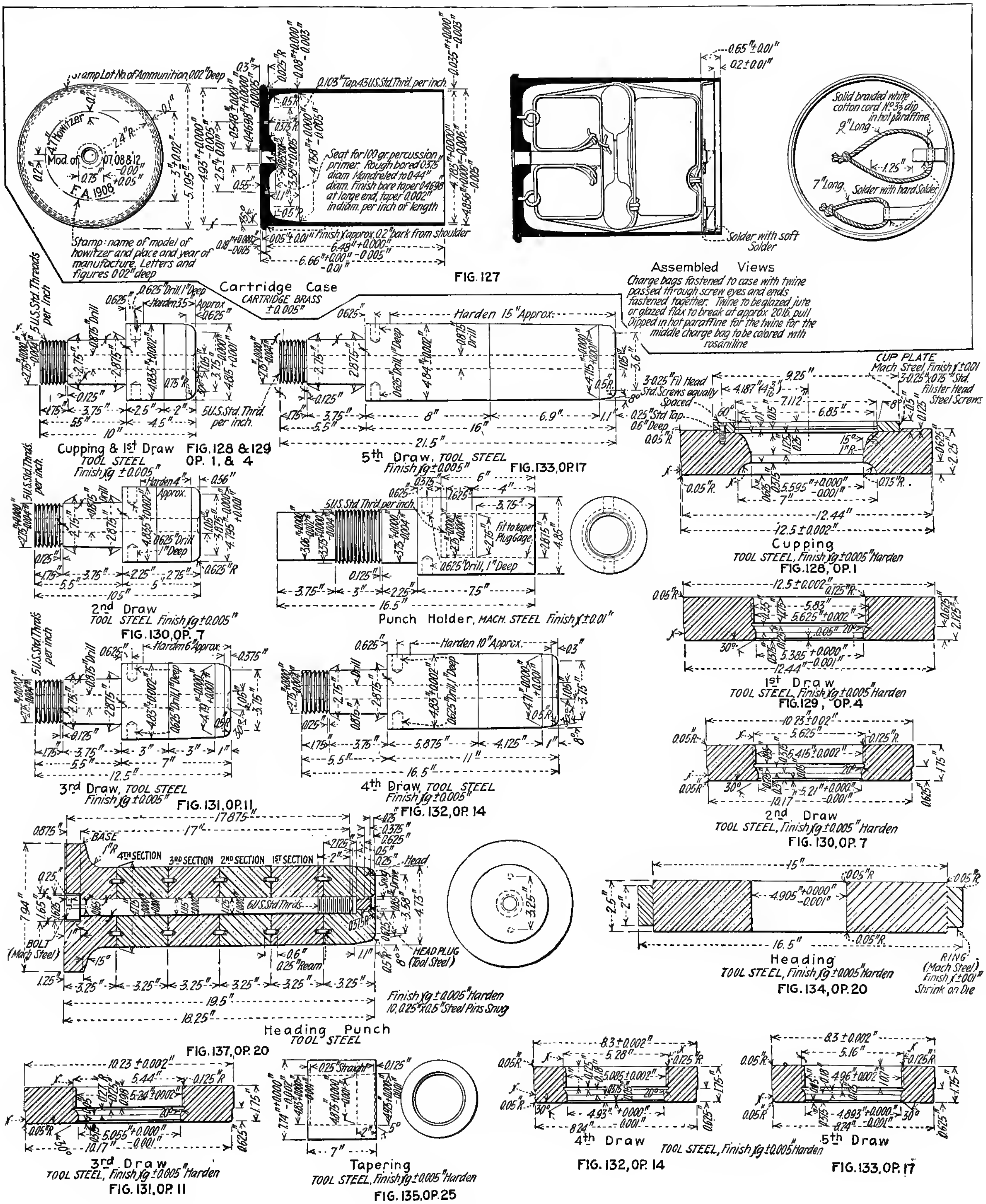


FIG. 116 — FIG. 117 Cupping — FIG. 118 1st Draw — FIG. 119 2nd Draw — FIG. 120 3rd Draw — FIG. 121 4th Draw — FIG. 122 5th Draw — FIG. 123 6th Draw — FIG. 124 A 7th Draw — FIG. 124 B 7th Draw — FIG. 125 A Head Punch, Head Pin — FIG. 125 B Heading — FIG. 1 Tapering

8 Wash and anneal
9 Pickle and wash
10 Third draw; punch and die, Fig. 131; pressure, 30 tons
11 Wash and anneal
12 Pickle and wash
13 Fourth draw; punch and die, Fig. 132; pressure, 20 tons
14 Wash and anneal
15 Pickle and wash
16 Fifth draw; punch and die, Fig. 133; pressure, 15 tons
17 Fifth-draw trim
18 Wash for heading
19 Heading; die, Fig. 134; pressure, 1350 tons
20 Rough-turn head and drill primer hole
21 Broach
22 Burr out
23 Point anneal
24 Taper; die, Fig. 135; pressure, 30 tons
25 Finish-turn head
26 Drill for screw-eyes
27 Tap for screw-eyes
28 Stamp; pressure, 15 tons
29 Final trim
30 Inspect



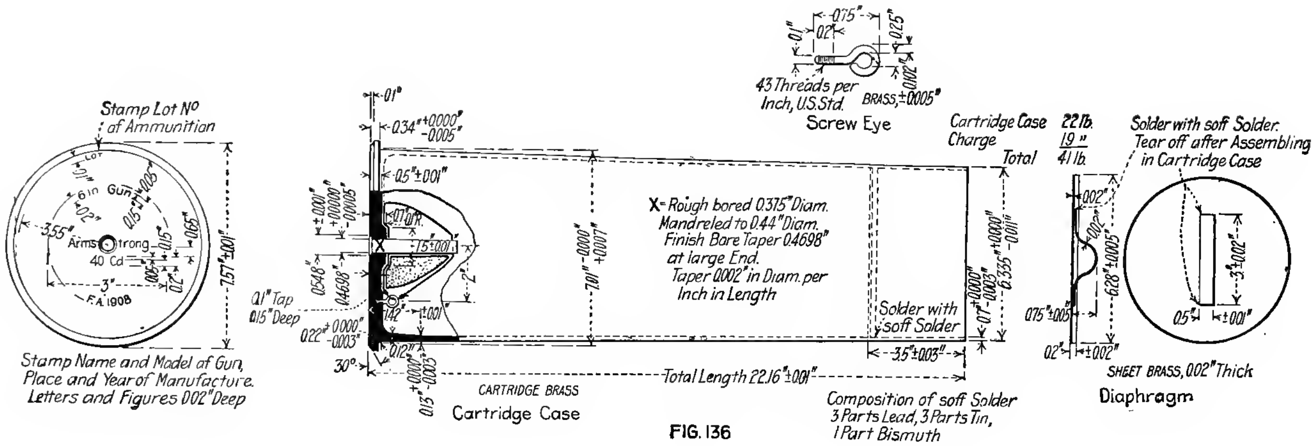


FIG. 136

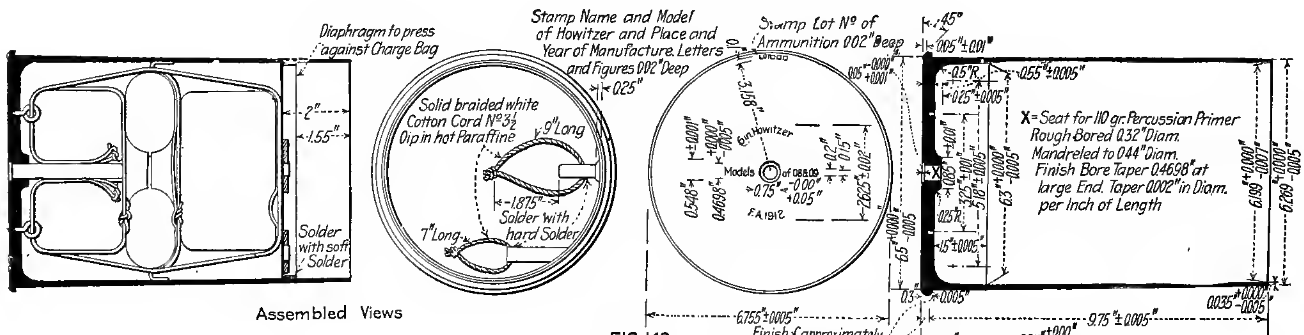


FIG. 149

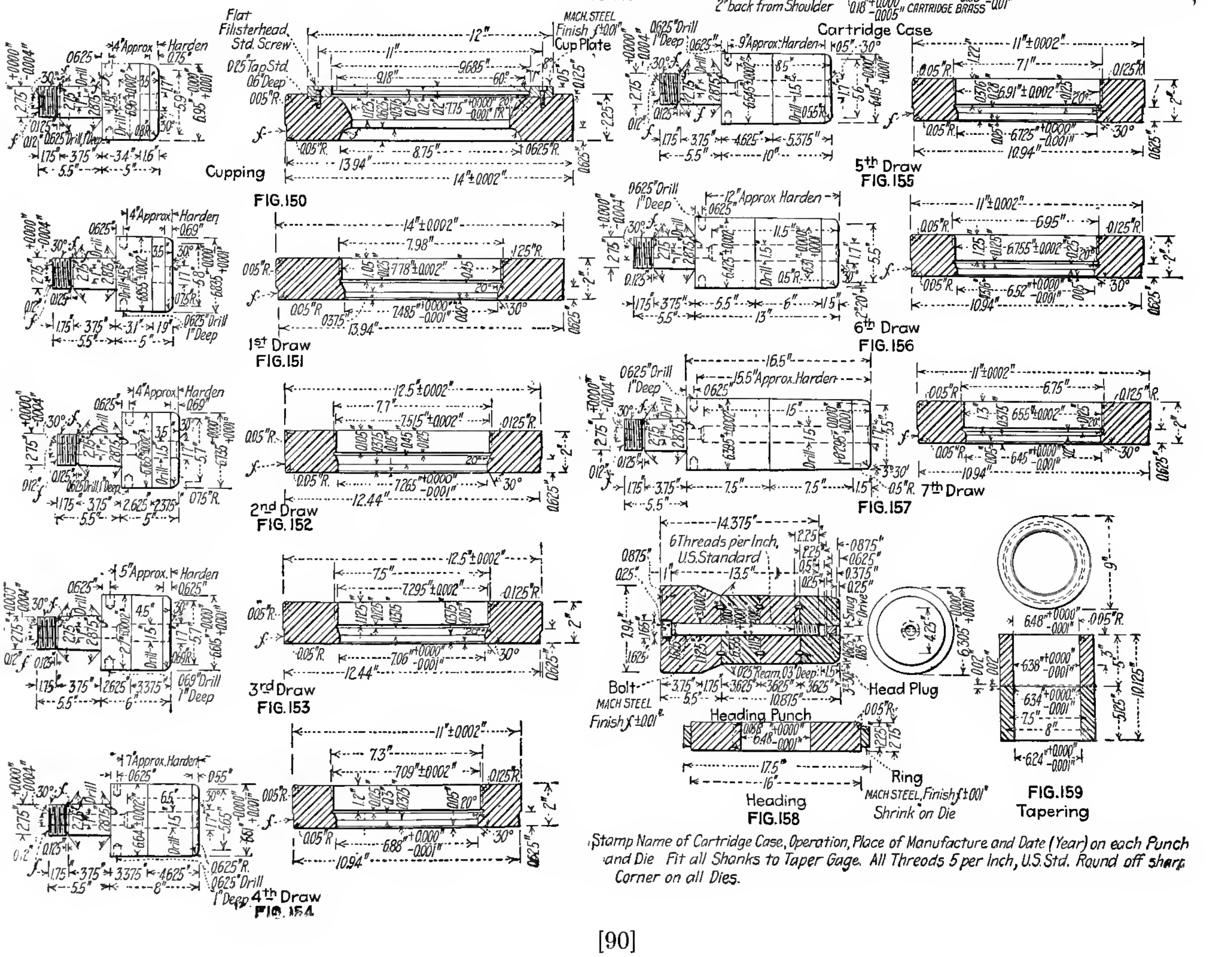


FIG. 150 Cupping

FIG. 151 1st Draw

FIG. 152 2nd Draw

FIG. 153 3rd Draw

FIG. 154 4th Draw

FIG. 155 5th Draw

FIG. 156 6th Draw

FIG. 157 7th Draw

FIG. 158 Heading

FIG. 159 Tapering

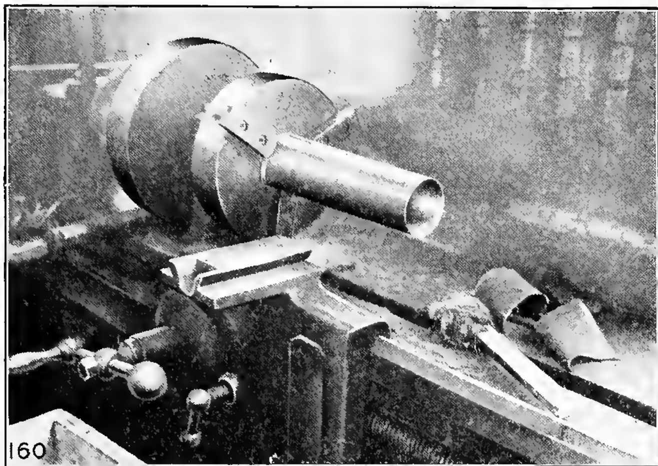
Cartridge Case for 6-In. Howitzer, Models of 1906 and 1908

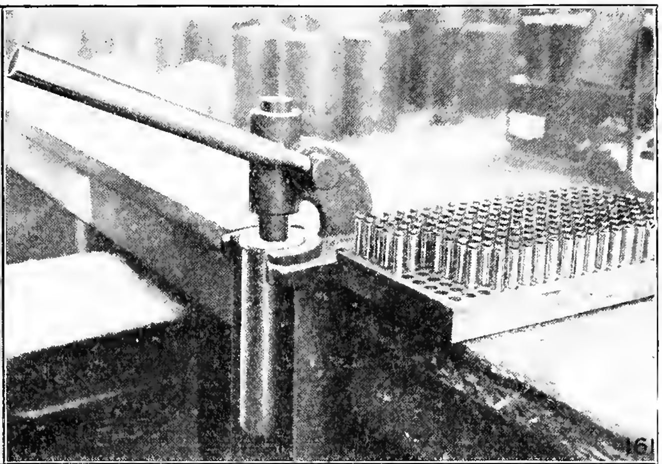
OPERATION 1. CUPPING

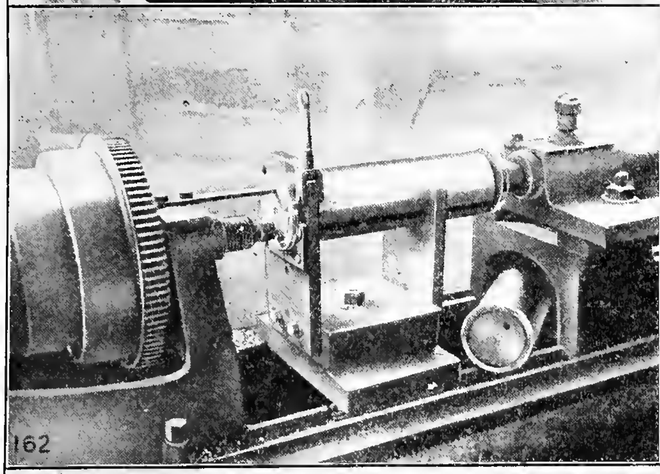
Details of Cartridge Case—Fig. 149. Punch and Die—Fig. 150. Pressure—75 tons. Dimensions of Disk—Maximum diameter, 9.680 in.; minimum diameter, 9.675 in.; maximum thickness, 0.405 in.; minimum thickness, 0.395 in.; weight, 9.0524 lb.

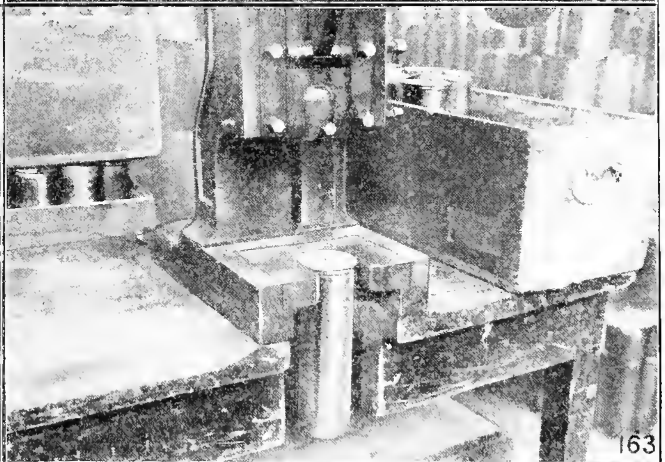
SUCCEEDING OPERATIONS

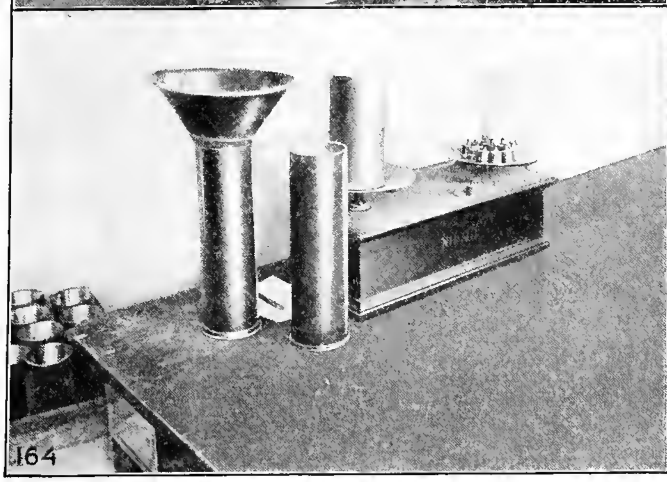
Operation	
2	Wash and anneal
3	Pickle and wash
4	First draw; punch and die, Fig. 151; pressure, 50 tons
5	Wash and anneal
6	Pickle and wash
7	Second draw; punch and die, Fig. 152; pressure, 45 tons
8	Wash and anneal
9	Pickle and wash
10	Third draw; punch and die, Fig. 153; pressure, 35 tons
11	Wash and anneal
12	Pickle and wash
13	Fourth draw; punch and die, Fig. 154; pressure, 30 tons
14	Wash and anneal
15	Pickle and wash
16	Fifth draw; punch and die, Fig. 155; pressure, 25 tons
17	Fifth-draw trim; trim 50 per cent.
18	Wash and anneal
19	Pickle and wash
20	Sixth draw; punch and die, Fig. 156; pressure, 25 tons
21	Sixth-draw trim
22	Wash and anneal
23	Pickle and wash
24	Seventh draw; punch and die, Fig. 157; pressure, 15 tons
25	Seventh-draw trim
26	Wash for heading
27	Heading; die, Fig. 158; pressure, 1800 tons

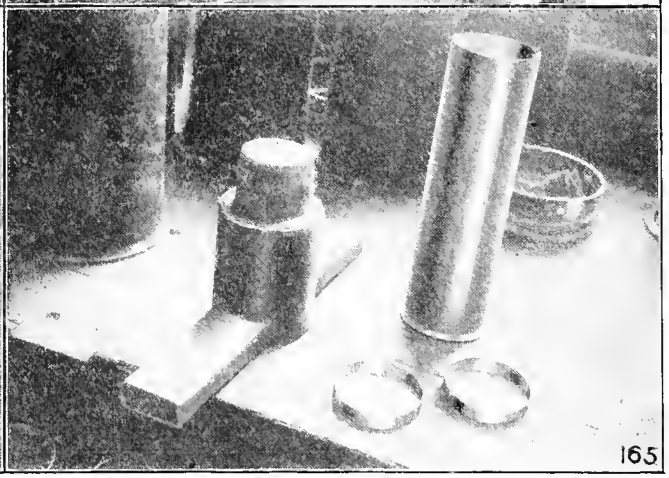












FIGS. 160 TO 165. PREPARING FOR THE LOADING OF THE PROPELLING CHARGE

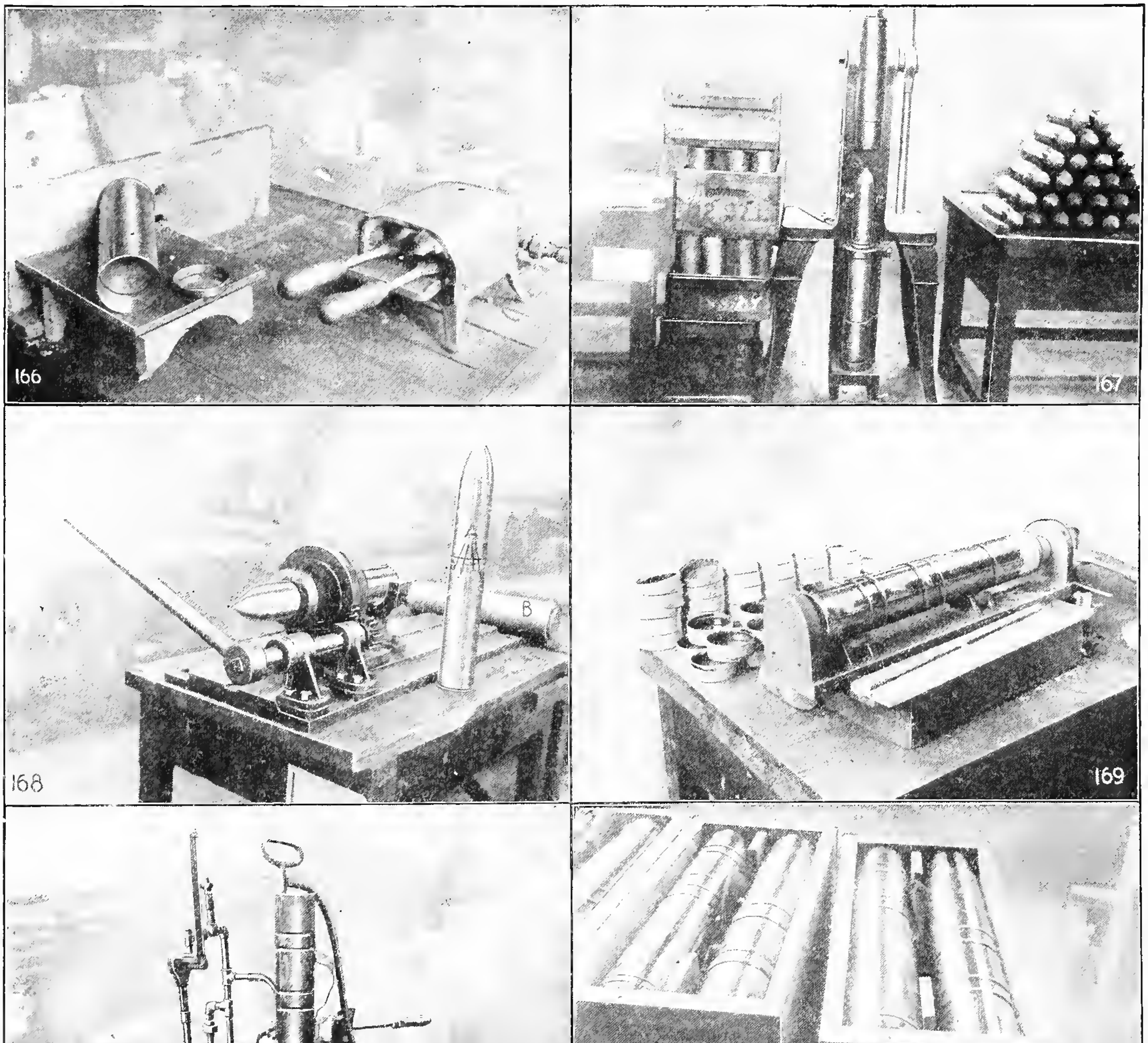
Fig. 160—Polishing the mouth. Fig. 161—Inserting primer. Fig. 162—Spot drilling for tracer mark. Fig. 163—Stamping lot number. Fig. 164—Weighing and putting in the powder. Fig. 165—Inserting the diaphragm

28 Rough-turn head and drill primer hole
29 Broach
30 Burr out
31 Point anneal
32 Taper; die, Fig. 159, pressure, 40 tons
33 Finish-turn head
34 Drill for screw-eyes
35 Tap for screw-eyes
36 Stamp; pressure, 13 tons
37 Final trim
38 Inspect

Loading the Propelling Charge and Assembling to Projectile

Like the various drawing and other operations on the cartridge cases, the loading of the propelling charge follows pretty closely along the same general lines, so that only one size will be followed through. In this particular case the powder is put loose into the case, but in others, especially in the howitzer types, the powder is placed in one or more bags. In the howitzer these bags are tied in by means of cords run through screw-eyes placed inside of the head. In a large number of cases the assembling is done in the field or just previous to actual use. This, however, has nothing directly to do with the manufacturing or machining processes, so will not be expanded upon here. The example chosen to illustrate the loading process is the case and projectile for the 3-in. field gun, models of 1902, 1904 and 1905, and the operations are:

1. Polish mouth
2. Insert primer
3. Fill color groove
3½. Spot for tracer paint mark



FIGS. 166 TO 171. VARIOUS ASSEMBLING, SOLDERING AND TESTING OPERATIONS

Fig. 166—Soldering in the diaphragm. Fig. 167—Pressing in the projectile. Fig. 168—Creasing machine. Fig. 169—Soldering on the can lid. Fig. 170—Testing for leaks. Fig. 171—Packed in boxes

4. Stamp lot number
5. Put in propelling charge
6. Insert diaphragm
7. Solder in diaphragm
8. Fill crimping grooves
9. Press in projectile
10. Crimp and drop in can
11. Solder on can top
12. Test and solder small hole
13. Varnish and box

The mouth of the case is polished to provide a clean bright surface for the soldering in of the retaining diaphragm. The case is chucked as shown in Fig. 160. As it turns, the operator holds emery cloth so as to polish out the mouth back for several inches. Waste on the end of a stick is also used to wipe the surface clean. Primers are inserted by means of a small hand press, as shown in Fig. 161. They are carried to the bench on board trays holding 200 primers.

All cartridge cases intended for use with projectiles having night tracers must be spotted with a blunt-end drill and the spot filled with red paint, as a distinguishing mark. The spotting of the head is done as shown in Fig. 162. The case is held in a guiding fixture and fed forward onto the drill by means of the tailstock spindle. A stop bolted to the top of the front lathe bearing is used to gage the depth of the spot.

The lot number is stamped in a hand press, as shown in Fig. 163. The order of some of these minor operations is occasionally varied according to changing shop conditions, but this is not important. In loading the propelling charge into this case, the required amount of powder is weighed out and poured into it, the outfit used being shown in Fig.164. The next operation after pouring in the powder is the pressing in of the diaphragm, which is done with the handled gaging plug illustrated in Fig. 165.

In getting ready to solder in the diaphragm the operator first polishes the inside edges of the diaphragm slightly with emery cloth and then proceeds to solder the edges to the case, using ordinary soldering coppers heated in a bench furnace as shown in Fig. 166.

Following the work on the diaphragm, the projectile is pressed in, as shown in Fig. 167, and then the case is crimped into the grooves at the base of the projectile, using the machine shown in Fig. 168. Continuous creases all around are not produced, but indentations like those at *A* are made. After crimping, the assembly is thrust into the gaging chamber *B* and then dropped into a tin can.

The can cover is next put on and soldered in place in the bench fixture, Fig. 169. The can is tested for leaks with the device illustrated in Fig. 170; and after varnish has been applied wherever the can has not been coated, it is ready for packing in boxes, shown in Fig. 171. Of this size, four cans are packed in each box. The boxes are then covered and nailed ready for shipment.

Loading 3-In. Cartridge Case and Assembling to Projectile for Field Gun

OPERATION 1. POLISH MOUTH

Machine Used—Lathe, Fig. 160. Number of Operators per Machine—One. Work-Holding Devices—Chuck; work runs at 475 ft. surface speed. Production—800 per day. Note—No. 2 emery cloth is used, and workman presses it inside of mouth to polish for soldering in diaphragm.

OPERATION 2. INSERT PRIMER

Machine Used—Small hand press, Fig. 161. Number of Operators per Machine—One. Production—1850 per day.

OPERATION 3. FILL COLOR GROOVE

Number of Operators—One. Description of Operation—Operator sets case on end and applies paint to the circular groove in the head. Apparatus and Equipment Used—Small round brush and can of paint. Production—2000 per day. Note—Colors: Red for high explosives, yellow for shrapnel and black for shell.

OPERATION 3½. SPOT FOR TRACER PAINT MARK

Machine Used—Lathe, Fig. 162. Cutting Tools—Blunt-point ⅜-in. gun drill. Cut Data—Spindle runs 600 r.p.m. Production—200 per hr. Note—Ten per cent. of the cases are drilled just enough to hold a dab of red paint to identify those carrying night tracers.

OPERATION 4. STAMP LOT NUMBER

Machine Used—Hand press, Fig. 163. Production—1700 per day.

OPERATION 5. PUT IN PROPELLING CHARGE

Number of Operators—One. Description of Operation—Operator weighs and pours charge of smokeless powder into each cartridge case, the amounts being 10,336 gr. for 3-in. shrapnel and 10,910 gr. for 3-in. common shell for field guns. Apparatus and Equipment Used—Scale, measure and funnel, Fig. 164. Production—950 per day.

OPERATION 6. INSERT DIAPHRAGM

Number of Operators—One. Apparatus and Equipment Used—Wooden plug inserting tool, Fig. 165. Production—110 per hr. Note—The shoulder on tool is 1⅞ in. back from the end of the plug.

OPERATION 7. SOLDER IN DIAPHRAGM

Description of Operation—Operator solders edges of diaphragm to the inside of the cartridge case, as shown in Fig. 166. Production—550 to 575 per day.

OPERATION 8. FILLING CRIMPING GROOVES OF PROJECTILE

Description of Operation—Operator brushes a mixture of 1 lb. beeswax to 3 lb. of tallow into the crimping grooves at the base of the projectile; this forms an air- and moisture-proof seal as the projectile is pressed into the cartridge case. Note—Operations 8, 9 and 10 are done by two men, with an output of 875 per day.

OPERATION 9. PRESSING IN PROJECTILE

Description of Operation—Operator places case in the holding fixture, sets a projectile in place and presses it down until the end of the case contacts with the copper band, as shown in Fig. 167. Note—This is the same for both the 3-in. common and the 3-in. shrapnel shell.

OPERATION 10. CRIMP AND DROP IN CAN

Description of Operation—The crimping machine, Fig. 168, does not crimp continuous grooves all around the case, but makes eight indentations, staggered as shown at A; after crimping, the shell is thrust into the cylinder gage B, which is the same size as the chamber of the gun; the operator next drops the shell into a tin can.

OPERATION 11. SOLDER ON CAN TOP

Description of Operation—Operator puts lid on top of can and places it on the rollers of the fixture shown in Fig. 169; he then securely solders the edges of the top to the can. Production—350 per day.

OPERATION 12. TEST AND SOLDER SMALL HOLE

Description of Operation—A small open air hole has been left in the bottom of the can; the operator places the can bottom up and thrusts the nozzle of an air hose into the air hole, as shown in Fig. 170; about 5 lb. air pressure is carried, and the air valve automatically opens as the nozzle is pressed to the can; as the operator presses down the nozzle, he watches the air gage; if it remains stationary the can is tight, the nozzle is removed and the air hole soldered up; if the can leaks, the place is located and soldered. Production—800 to 900 per day.

OPERATION 13. VARNISHING AND BOXING

Description of Operation—After being soldered, the can is varnished wherever it has not been previously coated, and then the cans are placed four in a box, as shown in Fig. 171. Production—1500 per day.

INDEX

(* Indicates Illustrations.)

3-in. Common Shrapnel, 1–25

ASSEMBLING:
- Balls, compressing, * 20, 21
- Case, filling, * 20, 21
  - pinning to head, 22, * 23, * 24
  - to head, 22, * 22
- Cosmoline, brushing on fuse threads, 24
  - moistening threads of head and case, 22, * 22
- Cover, crimping on, 24, 25, * 25
- Crimp on cover, 24, 25, * 25
- Diaphragm and tube, * 20, 21
- Grooving for waterproof cover, 22, 24, * 24
- Head, pinning to case, 22, * 23, * 24
  - to case, 22, * 22
- Lead powder charge, * 18, 24, * 25
- Lock fuse, 24, * 25
- Operation sequence, 7
- Painting, 22, 23, 24, * 25
  - interior, * 20, 21
- Resin, cutting out surplus, 21, * 21
- Screw in fuse, 24, * 25
- Set fuse to safety, 25, * 25
- Tube and diaphragm, * 20, 21
  - inner, inserting, 22, * 22
- Turning bourrelet, * 7, 22, * 23
- Wash case in soda water, * 20, 21

BALLS:
- Casting ingots, * 18, 19, * 19, 20
- Compressing in assembly, * 20, 21
- Extruding wire, * 18, 19, * 19, 20
- Forming on punch press, 18, 19, * 19, 21
  - on special machine, * 18, 19, * 19, 20
- Number used, 1
- Operation sequence, 7
- Rumbling, * 18, 19, 21
- Size, 1, * 19
- Weight, 6

BAND:
- See also under "Common Steel Shell."
- Assembling, 5, 10
- Description, 25
- Turning, * 2, 5, * 10
- Weight, 6

CASE:
- Assembling to head, 22, * 22
- Body, turning, * 2, 4, * 4
- Bourrelet, finishing, 4, * 7
  - turning, * 7, 22, * 23
- Centering, * 2, 4, * 4
- Dimensions, * 1
- Filling, * 20, 21
- Interior, finishing, * 2, 4, * 7, 10
  - painting, * 20, 21
- Operation sequence, 6
- Outside, finishing, * 2, 4, * 5, * 6, 7, 10
- Painting exterior, 22, 23, 24, * 25
- Pinning to head, 22, * 23, * 24
- Tapping for head, * 2
  - for night tracer, 5, * 8
- Testing, * 2, 5
- Washing, * 20, 21
- Weight, 6

Charge, see "Powder."

Cover, waterproof, grooving case for, 22, 24, * 24

DIAPHRAGM:
- Assembling with tube, * 20, 21
- Base, painting, 14, * 15, 15
- Drill and counterbore, 14, * 14, 15

DIAPHRAGM:—*Continued*
- Heat-treatment, 14
- Operation sequence, 7
- Scale, removing from counterbore, 14, * 15, 15
- Tube, assembling, 14, * 15, 15
- Weight, 6

FORGINGS:
- Chemical tests, 1
- Dimensions, * 1
- Phosphorus content, 1
- Physical tests, 1
- Sulphur content, 1
- Testing, 6
- Tool life turning, 6

FUSE:
- Assembling to case, 24, * 25
- Description, 1
- Setting, 1
  - to safety, 25, * 25
- Threads, brushing on cosmoline, 24
- Weight, 6

HEAD:
- Assembling to case, 22, * 22
- Countersink, * 9, 11, 12, * 12
- Details, * 10
- Locking fuse to, 12
- Machine, * 9, * 10, * 11, 12
- Notches, milling, * 9, 12, 13, * 13
- Operation sequence, 6, 11
- Painting, * 11, 12, 14
- Pinning to case, 22, * 23, * 24
- Production, 11
- Resin, facing off, * 11, 12, 14
  - filling, see "Head-retainer."
- Retainer, insert and fill with resin, * 9, * 11, 12, 14
- Tapping case for, * 2
- Thread, turning, 11, * 11, 13
- Washer, crimp in, * 9, * 13, 14
- Washing, 12, 14
- Weight, 6

HEAD FILLER:
- Weight, 6

Lathe tools, * 3

LOCKING PINS:
- Machining, 15, * 15

MATRIX:
- Weight, 6

Paint, proportions of, 23

POWDER:
- Amount, 1
- Loading, * 18, 24, * 25
- Weight, 6

RETAINER:
- Machining, 17, * 17
- Weight, 6

Tools, standard lathe, * 3, 10

TRACER:
- Description, 6
- Making, 25; see also "Common steel shell."
- Tapping case for, 5, * 8

TUBE:
- Assembling with diaphragm, 14, 15, * 15, * 20, 21
- Central, machining, 16, * 16
- Inner, machining, 16, * 16
- Weight, 6

WASHER:
- Punching, 17, * 17
- Weight, 6

3-in. Common Steel Shell, (High Explosive), 26–47
BAND:
See also "Band" under 3-in. Common Shrapnel; also under "Case."
Annealing, 43
Assembling to case, * 35, * 36, 37
Cutting from tubing, * 42, 43
Operations in machining, 47
Pickling, 43
Planishing, * 40, * 42, 43, 47
Tools used, * 35, 43
Turning, * 35, 37, * 37, 43
Washing, 43
Weight of, 29
BASE COVER:
See also "Loading."
Assembling to case, * 40, * 41, 41, 47
Weight of, 29
CASE:
Band, assembling, * 35, * 36, 37
seat, knurling, * 31, 33, 34
turning, * 32, 33, 34
turning, * 35, 37, * 37, 43
Base cover groove, finishing, * 34, * 36, 37
roughing, * 34, 35, * 35, 37
facing, * 32, 33, 34
finishing, * 27, * 29, 30, * 30, * 31, * 32, 34
notching, * 27, 33, * 34, 36
rough facing, 28, * 28, 30
Body, finishing, * 27, 33, * 34, 36
roughing, * 27, * 28, * 29, 30
Bourrelet, roughing, 36
Centering, 28, * 29
Counterboring, 34, * 35, 38
Gaging, * 28, 30, 33
Inspecting, 45
Interior, boring, * 27, * 32, 33, 36
rough boring, 34, 35, * 35
sand blasting, * 38, 38, 45
Operations on, 29
Point, finishing, * 32, 33, * 33
roughing, * 27, 28, * 29, 36
Tapping, * 30, 33, 34
Testing, hydraulic, * 36, * 38, 39, 45
Thread shoulder, * 29, 33, 37
Threading, * 31, * 35, 43
Threads, resizing, 34, * 35, 38
Tools used, * 27, * 29, 30
Weight of, 29
Cover, base, see "Loading."
Details of complete projectile, * 26
Detonator, 26
Explosive, see "Loading."
Forgings, details of, * 26
FUSE:
Assembling with case, 40, * 40, * 41, 47
Case, reaming hole in explosive for, 40, * 40, * 41, 47
Weight of, 29
Holding devices for various parts, 30, 36, 37
LOADING:
Cover, attaching and calking, * 40, * 41, 41, 47
Explosive, 26
compressing, * 39, 40, 47
filling case with, 39, * 39
nature of, 46
reaming hole in, 40, * 40, * 41, 47
weight of, 29
Fuse, screwing into place, 40, * 40, * 41, 47
Operations involved, 45
Painting exterior, * 40, 40, * 41, 47
interior, 39, * 39, 45
Threads and counterbore, cleaning, 40, * 40, * 41. 47
LOADING:—*Continued*
Tools for, * 41, 47
Tracer, screwing into place, 41, * 41, 47
Weighing case, * 39, 39, 46
NIGHT TRACER:
Assembling with case, 41, * 41, 47
Counterboring, drilling, and tapping, 43, * 43
Drilling, counterboring, and tapping, 43, * 43
End, facing and threading, 44, * 44
trimming, 46, * 46
Facing end and threading, 44, * 44
Loading, counterboring powder, 46, * 46
ignition mixture, 46, * 46
illuminating powder, 46, * 46
operations, * 46, 47
retarding mixture, 46, * 46
Operations in machining, 47
Tapping, drilling and counterboring, 43, * 43
Trimming end, 46, * 46
Use of, 26
NIGHT TRACER DISKS:
Ignition tube, assembling to outer disk, 44, *45
Ignition tubes, milling, 44, * 45
turning, 44, * 45
Inner disk, punching, 44, * 44
Operations on, * 44, * 45, 47
Outer disk, assembling to ignition tube, 44, * 45
punching, 44, * 45
Painting, see "Loading."
Trinitrotoluol, see "Loading."
Weight of various parts, 29

3-in. United States Navy Projectiles, 48–55
Air vents, cutting in sinusoidal ribs, 53, * 53
American Car & Foundry Co., 48
Band, fitting, 53, * 53
roughing and finishing, * 53, 54, * 54
score and base, turning, 49, * 49, 51
cutting sinusoidal ribs in, 52, * 52, * 53
maintaining position of, 53
Base and land score, turning, 49, * 49, * 51
facing, 49, * 49
hole in, drilling, 48, 49
marking, * 50, 52
reaming, counterboring, and tapping, * 53, 54
Body, finishing, 50, * 50
roughing, 50, * 50, * 51
Bourrelet, finishing, 50, * 50
Carriage, special for roughing body, 50
Centering, 48, * 49
Centers, drilling, 48, * 49
Cuts, drilling base, 49
turning base, 49
facing base, 50
roughing band score, 50
finishing band score, 50
roughing body, 50
finishing body and bourrelet, 50
roughing and finishing point, 51
cutting sinusoidal ribs, 53
turning band, 54
Dimensions of projectile, * 48
Eccentricity, testing forging for, 49, * 49
Facing base, 49, * 49, 50
Feeds, drilling base, 49
turning base, 49
facing base, 50
roughing band score, 50
finishing band score, 50
roughing body, 50
finishing body and bourrelet, 50
roughing and finishing point, 51

Feeds, cutting sinusoidal ribs, 53
turning band, 54
counterboring fuse hole, 54
Forgings, details of, * 48, * 51
distortion of, 49
testing for eccentricity, 49, * 49
Fuse hole, reaming, counterboring and tapping, * 53, 54
Gaging, * 50, 52, 52
for facing base, 50, * 50
Holding projectile, methods of, 48, 49, * 49, 50, * 50, 51, 52, * 52, 53, 54
Hole for fuse, reaming, counterboring and tapping, * 53, 54
Hole in base, drilling, 48, 49
Interior, lacquering, * 54, 55
washing, * 54, 55
Lacquering interior, * 54, 55
Loading, 55
Lubricants, drilling base, 49
turning base and band score, 49
finishing band score, 50
finishing body and bourrelet, 50
roughing and finishing point, 51
cutting sinusoidal ribs, 53
turning band, 54
tapping fuse hole, 54
Machines, type necessary, 48
Marking base, * 50, 52
Painting, 55
Point, finishing, 50, * 50, * 51
roughing, 50, * 50, * 51
Pressure for landing, 54
Sinusoidal ribs, cutting, 52, * 52, * 53
cutting air vents in, 53, * 53
Speeds, drilling base, 49
turning base, 49
finishing band score, 50
roughing body, 50
finishing body and bourrelet, 50
roughing and finishing point, 51
cutting sinusoidal ribs, 53
turning band, 54
counterboring fuse hole, 54
tapping fuse hole, 54
Testing, 50, 52, * 52
Tools, turning band score and base, 49, * 49, * 50
turning point, * 50, 51
turning sinusoidal ribs, 52, * 53, 53
turning band, * 53, 54
reaming, counterboring and tapping base, 54
Washing, * 54, 55
Weighing, 52, * 52

3.8, 4.7 and 6 in. Common Shrapnel and High Explosive Shells, 56–61
3.8-in. Common Shrapnel (30 lb.), 56
Band, see "Case."
CASE:
Band, assembling with case, 56
turning, 56
Body, turning, 56
Bourrelet, finishing, 56
roughing, 56
Centering, 56
Dimensions, finished, 56, * 56
Exterior, finishing, 56
Head, assembling, 56
disassembling, 56
finishing, 56
Hydraulic test of, 56
Interior, finishing, 56
Ogive, roughing, 56
Painting interior, 56

CASE:—*Continued*
Washing, 56
Diaphragm, operations on, 58
Forging, details of, 56, * 56
HEAD:
Countersinking, 58
Filling, 58
Grooving for cover, 58
Inspect, 58
Machining from bar, 58
Notches, milling, 58
Painting inside, 58
Pin to case, 58
Reassemble to case, 58
Resin, cut out surplus, 58
Retainer, placing, 58
Threading, 58
Threads, coating with cosmoline, 58
Tube, insert, 58
Washer, crimping, 58
Loading operations, 58
Locking pins, machining, 58
Projectile, details of complete, 56, * 56
Retainer, machining, 58
TUBE:
Central, machining, 58
Inner, machining, 58
inserting in head, 58
WASHER:
Crimping, 58
Punch, 58

4.7-in. Common Shrapnel (60 lb.), * 57, 58
6-in. Common Shrapnel (120 lb.), * 57, * 58, 59
3.8-in. Common Steel Shell Model 1905, 59, * 59
4.7-in. Common Steel Shell Model 1905, 59
BAND:
Assembling with case, 59
Turning, 59
BASE PLUG:
Machine from bar, 59
Notching base, 61
Thread, external, cutting on lathe, 59
external, milling, 61
internal, milling, 59
Wrench slots, milling, 61
CASE:
Band, assembling with case, 59
turning, 59
Base cover grooves, machining, 59
machining interior and exterior, 59
Body, finishing, 59
roughing, 59
Bourrelet, finish grinding, 59
roughing, 59
Dimensions of, 59, * 60
Heat treating, 59
Hydraulic test, 59
Point, finishing, 59
Threads in base, milling, 59
Forging, dimensions of, 59, * 60

6-in. Common Steel Shell, 61
6-in. Naval Shells, 62–70
Band, cutting grooves in, 68
finishing, 68
score, 65
Banding, * 65, 66
Base, counterboring, 68
marking, * 65, 67
plugs, installing, 69, * 69, * 70
machining, 69

Base, plugs numbering, 69
rounding, 65
threading, 68, * 68
Boring heads and bars for interior, * 64, 65
Bourrelet, finishing, 68
Cavity, see "Interior."
Center of gravity, 62
Centering forgings, 63, * 63
Centers, drilling in forging, * 63, 64
Chucks for holding shells, 62
Concentricity, 62
Cost of equipping machines, 69
Cost of shells, 69
Counterboring base, 68
Cuts, roughing body, 65
roughing and finishing interior, 65
Eccentricity, gaging for, * 66, 67
Essentials of machining, 62
Feeds, roughing body, 65
finishing outside, 68
Finishing outside, * 66, 67, * 67
Forgings, centering, 63, * 63
details of, * 62, 65
setting correctly for turning outside, 64
Gaging, 63, * 63, 64, * 66, 67, * 67, 68
Groove at rear of band, cutting, 68
Holding projectiles, methods of, 62, 64, 65, 66, 67, 68, 69
Interior, boring, 65
lacquering, 69, * 70
Lacquering interior, 69, * 70
Lubricant, turning body, 65
boring interior, 65
finishing outside, 68
Machines, methods of setting-up, 62
Marking size before finishing, * 66, 67
Outside, finishing, * 66, 67, * 67
rough turning, * 63, 64, * 64
Painting, 69, * 70
Plugs, installing base, 69, * 69, * 70
machining base, 69
numbering base, 69
Pressure applied in banding, 67
Radius, finishing, 68
turning attachment, * 63, 64
Sinusoidal ribs, * 64, 65
cutting air vents in, * 64, 66
Size, marking before finishing, * 66, 67
Speeds, roughing body, 65
roughing and finishing interior, 65
finishing outside, 68
Threading base, 68, * 68
Tongs for handling shells, 69, * 69
Tools, for turning outside of body, 64, 65
for boring interior, * 64, 65
rounding base, cutting band score and sinusoidal ribs, 65
finishing outside, 68
Washing, 69, * 69, * 70
Weighing, * 66, 67, * 67, 68, 69
Weight, 62

3- to 6-in. Cartridge Cases, 71–93
3-in. Field Gun Case, Models 1902, 1904, 1905, 72–80
Anneal and wash, 72, * 73, 74, 75, 76
Assembling to projectile, see "Loading."
Broaching primer hole, 76, * 77
Cupping, 72, * 72, 73, * 73, * 74
Detailed drawing, 72, *72
DIAPHRAGM:
Assemble with tube for tracer, 81
DIAPHRAGM:—*Continued*
Blanking, 81, * 82
Details of, 72, * 72
Forming, 81, * 82
Operation sequence, 80
Piercing, 81, * 82
Solder to tracer tube, 81
Drawing, * 72, * 73, * 74, * 75, 76, * 76
Finish trim, 78, * 78, * 80
Head, finishing, * 76, 77, * 78, * 79
roughing, * 75, 76
Heading, * 72, 75, * 75, * 76
Inspecting, 78, * 79, * 80, * 81
LOADING AND ASSEMBLING TO PROJECTILE:
Can, placing in, * 92, 93
soldering test hole, * 92, 93
soldering top, * 92, 93
testing for leaks, * 92, 93
Charge, nature of, 92
placing, * 91, 93
Color groove, filling, 93
Crimping, * 92, 93
grooves, filling, 93
Diaphragm, inserting, * 91, 93
soldering, * 92, 93
Mouth, polishing, * 91, 93
Number, stamping, * 91, 93
Operation sequence, 92
Projectile, pressing in, * 92, 93
Primer, inserting, * 91, 93
Spot for tracer point mark, * 91, 93
Operation sequence, 73
Ordnance department specifications, 71
Pickle and wash, 72, * 73, 74, 75, 76
Point annealing, 77, * 78
PRIMER:
Hole for, broaching, 76, * 77
burring, * 75, 77, * 77
drilling, * 75, 76
punching, * 72, * 75, * 76, 77
Position of, 72, * 72
Specifications, 71
Stamping head, * 72, 77, * 78, * 79
Tapering, 77, * 78, * 79
TUBE FOR TRACER:
Annealing, 81
Assemble with diaphragm, 81
Blanking, 81, * 82
Drawing, 81, * 82, * 83
Operation sequence, 80
Pickling, 81
Solder to diaphragm, 81
Trimming, 81, * 83
Washing, 81
Trim, finish, 78, * 78, * 80
Trimming, * 72, * 73, * 74, 75, 77, * 78, * 80
Wash and anneal, 72, * 73, 74, 75, 76
Wash and pickle, 72, * 73, 74, 75, 76
Washing for heading, 75

3-in. Mountain Howitzer Case, Models 1907 and 1911, * 80, 81, 82, * 84
3-in. Gun Case, 15 Pounder, Model 1898–1902, 82, 83, * 85
3-in. Gun Case, 15 Pounder, Model 1903, 83, * 86
3.8-in. Howitzer Case, Model 1908, 87, * 87
4.7-in. Gun Case, Model 1906, 88, * 88
4.7-in. Howitzer Case, Models 1907, 1908 and 1912, 88, 89, * 89
6-in. Gun Case, * 90
6-in. Howitzer Case, Models 1906 and 1908, * 90, 91